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1. MANAGEMENT

Gas Industry Management

California Has New Source of Gas—Almost. *Oil Gas J. 58,* 88 (1960) Aug. 1.

A $191 million pipeline system is ready to move its first gas into California, but the flow is being blocked by a dispute over the delivery price of the gas. Transwestern Pipeline Co. wants 43 cents/MCF for the gas at the California-Arizona border. Its California customer, Pacific Lighting Gas Supply Co., wants to pay only 42¼ cents a thousand. The dispute is before the Federal Power Commission, but no decision has been made.

Midyear Report. Why Gas Prices Are High. *Oil Gas J. 58,* 172 (1960) July 25 (3 pp.)

Increase in consumer prices is not due entirely to higher field prices; some pipelines and utilities have taken a bigger share of the total than producers. A few have held down or even reduced their percentage of the total price. In most cities, prices to residential and commercial customers have risen faster than prices to industrial users. The average of all consumer gas prices increased 11.6 cents per MCF from 1953 to 1958. But producer prices rose only 3.9 cents per MCF; the remainder came from higher charges by transmission and distribution lines.

A Management Look at Natural Gas. M. B. Golush. *J. Petrol. Tech. 12,* 11 (1960) July (6 pp.)

Author believes that, pending acceptable solution to regulatory problems, aggressive natural gas exploration should continue—but it should be concentrated in areas offering the required incentive prices. He states that sales should be made preferentially into nonjurisdictional markets, or to those markets offering the greatest wellhead revenues. Current and future situations are analyzed.

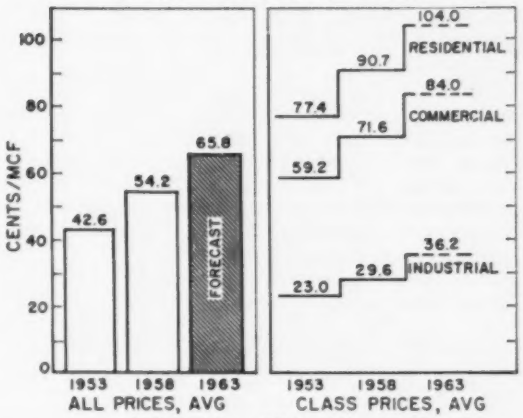
Some Considerations in the Pricing of Natural Gas. K. E. Hill. *J. Petrol. Tech. 12,* 17 (1960) July (2 pp.)

Article differs from that of Golush (see above) in that author believes that pricing problems of natural gas producing industry stem from large volumes of gas heretofore committed at very low prices for very long periods—not from prices on newly discovered and dedicated gas reserves.

A Suggested Form of General Rules and Regulations for the Conservation of Oil and Gas. (Sub-Committee of the Regulatory Practice Committee, Interstate Oil Compact Commission.) June 1960 (16 pp.)

The Regulatory Practices Committee appointed a subcommittee which revised the suggested rules prepared in 1950. The full Committee adopted the rules, and recommended the same action to the Commission. The Commission, after so doing, directed that these be published and distributed. These rules are not applicable in all states; thus several alternate rules are being suggested. Detailed statements of 39 rules are given.

Consumer Price Trends of Gas



(Adapted from *Midwest Report: Why Gas . . .* See Abstract at left)

Gas Industry Expansion

Natural Gas Construction Data (1960 Edition). (New York: Gas Appl. Manu. Assoc., Inc., 41 pp. $3.00)

At the end of 1959, proved recoverable reserves of natural gas were at an all-time high of 262.6 trillion CF, despite a net production of 12.4 trillion CF during the year. Three different sources have estimated the possible maximum which U.S. proved reserves of natural gas might reach. These are: the U.S. Geological Survey, 1700 trillion CF; the A.G.A., 1400 trillion CF; and the Chase Manhattan Bank, 1200 trillion CF. The report is divided into two parts: natural gas construction authorized by the FPC during 1959, and major natural gas construction applications pending hearing and disposition of the FPC on January 1, 1960. Supplementary data include recaps of pertinent developments during the first four months of 1960; a list of cities of 50,000 population or more which will receive benefits from authorized construction; names and addresses of companies undertaking major construction, and a summary table depicting over-all activity during 1959 in terms of miles of main, estimated net tonnages of steel required, horsepower of compressors installed and total costs of projects.

Appliances

Safety Devices for Domestic Gas Appliances. R. Brisou. *J. Ind. Gaz 84,* 251 (1960) June (12 pp. French text.)

Second part of a presentation of safety devices used in France and abroad for domestic gas appliances.

Education

Southern Tech Fuel Gas Course Booming. C. A. Childers. *LP-Gas 20,* 25 (1960) July (3 pp.)

Author explains the extent and scope of technical training offered, and the problems encountered, by means of a history of the Southern Technical Institute and the gas fuel technology course.

Federal Power Commission

Can Gas Producer Regulation Be Made Workable? E. Falck. *Public Util. Fortnightly 66,* 73 (1960) July 21 (15 pp.)

With the changing political atmosphere which has settled down since the 1954 Supreme Court decision in the Phillips case, it seems only realistic today to assume that FPC regulation of gas producers is here to stay. If that is a sound position, it seems that arriving at some workable and acceptable program whereby the producers can live with such regulation is a more practical approach than continued resistance to it. This article reviews broadly what has happened to date in this troubled jurisdictional sea into which a reluctant FPC was pitched by the 1954 court decision, and in which it has been struggling ever since, amid swiftly changing currents and few if any clear or reliable navigating guides.

Current Fallacies in Regulation. F. X. Welch. *Public Util. Fortnightly, 66,* 16 (1960) July 7 (9 pp.)

For over 300 years, the main purpose of regulation has been to assure the customer of service. The earliest regulatory statutes did not even contain any rate-fixing authority at all. That came later as part of the objective of assuring the public that an adequate and essential service would be available to it without discrimination. The author examines certain misconceptions that seem to dominate the thinking of many concerned with utility regulation today. He notes that commission regulation, while in need of strengthening and improvement, is the best possible method yet devised for good service at reasonable cost.

Foreign Activities

Australia's Roma Area Gas Field Gets Bigger. *Oil Gas J. 58,* 81 (1960) July 4.

A Queensland well, the Pickanjinnie No. 1, an apparent extension of the Roma gas area, flowed 2½ MMCF/day on a 40-minute test. The flow, the largest recorded in Queensland, came from an 18-ft zone at 4007 ft. Bottom hole pressure was 1800 psi. Three other producers in the Roma area are the Timbury Hills No. 2, one at Hospital Hill and a fourth at Warooby. These wells flow at rates of 1¼ MMCF/day, more than 1 MMCF/day and 500 MCF/day, respectively. On the other hand, present demand for natural gas in Australia is about 1 billion CF/day.

Fuels for a Growing Country Through SARGO Pipelines. *World Petrol. 31,* 47 (1960) July (5 pp.)

Twin oil and gas lines from Campo Duran are a major contribution to Argentina's economic development. Project is unique in that both the 1100-mile 22- and 24-in. gas pipeline and the 900-mile 12-in. products line have been built together as one project. Supply for both lines comes from the Madrejones and Campo Duran fields, gathered in a dual pipeline system and processed in a single gasoline plant. Lines have a capacity to deliver 243 MMCF/day of gas and 57,860 bbl/day of liquid products.

Latin American Utilities' Nationalization Proceeds Inexorably. H. Bratter. *Public Util. Fortnightly 66,* 1 (1960) July 7 (15 pp.)

American and other foreign-owned utilities in Latin America have been subjected to increasing forms of harassment which seem destined to squeeze them out. Plants have been expropriated. Rates have been reduced or kept to a minimum. The government has built its own generating stations and assisted in the building of community co-op power plants. Latin America needs a plentiful supply of power to develop its economy. But electric service is chronically underpriced there. This makes it difficult, if not impossible, for utilities to generate enough capital to help them finance the expansion that seems required. In a country with no organized capital market, such a situation is indeed an adverse one, says author.

The National Oil Future. D. M. Soifer. *World Petrol. 31,* 43 (1960) July (4 pp.)

Author predicts that Argentina will achieve self-sufficiency in liquid fuels in 1962, but will still have to import 1,500,000 m^3 in 1960 and 4,400,000 m^3 in 1960-61. After 1961, refinery capacity will exceed liquid oil consumption. In 1960, gas will contribute 10.2% to the liquid fuels balance, more than double the 1959 figure. In 1961, it will rise to 13.4%, in 1962, to 15.1%, in 1963 to 16.6%, and in 1964 to 31.9%.

Natural Gas Lifts Argentina's Fuel Load. *World Petrol. 31,* 76 (1960) July (2 pp.)

Gas industry is being boosted in Argentina by means of such projects as the Campo Duran which joins the Salta fields with important consumption centers. The line, which went onstream in 1959, has increased the availability of natural gas by 700% or 247.3 MMCF/day. Other important lines just completed or scheduled are those in Barker province, Tucumán and Buenos Aires province. Also under consideration is a plan to expand gas service across the country's borders to supply Uruguay, Paraguay and Chile.

North Africa: Activity from the Nile to Atlantic. R. G. Gibson. *Oil Gas J. 58,* 138 (1960) July 25 (3 pp.)

In the five years since the first oil discovery in the Sahara, Africa has witnessed the growth of exploration, listened to companies bid on acreage and been invaded by five major pipeline systems. There are five major commercial developments: Hassi Messaoud, Edjele-Zarzaitine, Hassi R'Mel, Zelten and Dahra. Article surveys progress.

Oil Won't Be a Big Problem for Cuba. *Oil Gas J. 58,* 57 (1960) July 11 (3 pp.)

Cuban Premier Fidel Castro confiscated Esso Standard's 36,500-bbl Belot refinery and Cia. Shell de Cuba's 27,000-bbl Havana refinery 2 days after taking over Texaco's 20,000-bbl plant at Santiago de Cuba. Grounds were that the companies refused to process Russian crude. Cuban officials, meanwhile, continue to boast they will get away with the seizure. Alfonzo Gutierrez, the Mexican engineer who heads the Cuban Petroleum

Institute, says 18 tankers are enroute to Cuba with Russian crude from Black Sea ports.

YPF's Lujan de Cuyo—Argentina's Newest Refinery—An International Project. C. M. Wooley and M. J. Carnesale. *World Petrol. 31,* 52 (1960) July (3 pp.)

Largest current refinery project in Argentina is Yacimientos Petroliferos Fiscales' new 28,300 bbl/day expansion in Mendoza, a western province next to the Andean frontier that separates Chile and Argentina. The Lujan de Cuyo refinery installations will triple the former crude refining capacity and will produce a wider range of products including both high and low-octane gasolines, kerosenes, jet and tractor fuels, fuel oil, liquid petroleum gases, and coke.

Helium

New Plant Counters Helium Shortage. *Chem. Eng. 67,* 96 (1960) July 25 (4 pp.)

U.S. Bureau of mines remedied a shortage with its new 290 MMCF/yr plant at Keyes, Okla., for extracting high-purity helium from natural gas. U.S. helium capacity is comfortably ahead of demand for the first time in several years. A solution for the conservation problem also appears possible. Congress is currently studying proposed legislation under which privately-owned firms would extract a crude (perhaps 75%) helium stream from natural gas. The Bureau would buy the crude material, store it, then refine and sell it to meet existing demand. Flow sheet and cost estimates are included.

LPG

Who'll Buy Alberta's Surplus LPG? G. T. Kinney. *Oil Gas J. 58,* 57 (1960) July 18 (3 pp.)

One of the biggest controversies among the four competing companies, eager to build pipelines to move Alberta's liquids, concerns the size of the surplus, and when it will develop. According to author, it will come as new wet gasfields start producing and new plants begin processing a volume that will eventually reach 650,000,000 CF/day for export to the western U.S. Normal processing operations will turn out a volume of gas-liquid products ranging somewhere between 60,000 and 91,000 bbl/day. Over half of this will be surplus that will be looking for a market.

Operations Research

A Farewell to the Cookbook. D. Q. Kern and O. O. Kenworthy. *Ind. Eng. Chem. 52,* 42A (1960) Aug. (6 pp.)

Modern techniques of optimization are adaptable to formulation and compounding problems, once evaluation test results have been combined into a single figure of merit. The composite nature of the figure of merit may greatly simplify the final stages of the optimization procedure, by providing a functional relationship in terms of the evaluation variables without resorting to elaborate experimental designs or the fitting of nonlinear functions.

Petrochemicals

Petrochem Output: Sharply Upward Again. Ethylene Remains No. 1 in Popularity. *Oil Gas J. 58,* 61 (1960) July 18.

Production of basic petrochemicals is expected to surpass the 1959 figure, which was a 16% increase over 1958. Outlook is based on the latest study by the U.S. Tariff Commission. Its preliminary report shows a figure of 24,277 million lb in 1959, compared to 20,903 million lb in 1958. If the expected trend continues, the production total should approach 30 billion in 1960.

Pipeline Construction

Cost of Pipelines in the U. K. A. E. Crisp and P. W. Heselgrave. *Petrol. 23,* 249 (1960) July (3 pp.)

Paper discusses the costs of steel pipelines in the U. K. with a view to giving costs which are sufficiently accurate for general economic and feasibility studies on projects requiring such lines. Authors suggest that a figure of £1000 per inch diameter per mile is satisfactory for a rough estimate. There are three main reasons for variations in costs: a) dependence on the nature of the route, b) the type of line and its purpose and c) the state of the market for construction services. The total cost of a pipeline comprises the following items: 1) design, 2) legal charges, 3) land easement and compensation payments, 4) material costs, 5) construction costs, 6) supervision and inspection, 7) cathodic protection costs, and 8) testing and commissioning.

California Gas Line Approved Over Protests. *Oil Gas J. 58,* 134 (1960) July 25.

Rock Springs project, which will deliver 470 MMCF/day of natural gas to California from Canada, the Rockies and the Texas Panhandle, received the approval of an FPC examiner. The joint $150-million project is planned by Colorado Interstate Gas Co. and El Paso Natural Gas Co.

Rising R.O.W. Costs! What Can We Do About It? J. G. Reichel. *Pipe Line News 32,* 21 (1960) July (2 pp.)

Author presents cross section of ten opinions, as well as his own, pertaining generally to cross-country right-of-way. While it would be impossible to determine all the factors responsible for rising costs, there are some important items which contribute to the subject. Among these are: location, crash programs, sharp instruments, legal action (or lack of it), public relations, and methods to acquire right-of-way grants.

Texas-Mexico-California Line Studied. *Oil Gas J. 58,* 62 (1960) July 11 (2 pp.)

Southern California Edison Co., Los Angeles, is understood to have firmed up an imaginative scheme involving Tennessee Gas Transmission Co., Houston-based transmission firm and integrated oil company; Petroleos Mexicanos, the Mexican Government oil agency; and several U. S. producers. The project is reported to be an 1100-mile, 34-in. line from Laredo, Texas, across northern Mexico to Mexicali, on the California border. Initial volume will be made up of 70 MMCF/day from South Texas fields and 125 MMCF/day from Mexico; 70 MMCF would be delivered to Mexican industries along the route.

Process Design

How to Control Total Costs. K. J. Gutshaw. *Petrol. Refiner 39,* 112 (1960) July (3 pp.)

Effective control of plant costs depends upon a close working relationship between 1) the plant engineer, who supplies the process and budget information required for the development of the dollar norms for control, and 2) the professional accountant, who, because he works with the engineer, is able to develop and modify the systems that will faithfully reproduce plant activity and report actual operating results that can logically be compared with the norms that have been established. In the petrochemical business, product manufacturing cost consumes a major portion of the sales dollar and, as a result, considerable effort is concentrated on minimizing this particular cost.

Research

Trends in Industrial R/D. Y. Brozen. *Research/Development 11,* 5 (1960) Aug. (9 pp.)

Research in the laboratories of U.S. industry has grown for the past 25 years at a rate in excess of 15%/yr in dollar terms and 12%/yr in real terms. Growth in some industries has been rapid; others have fallen far short of these rates.

Safety

How to Build Safety into a Transport. C. Jarvis. *Butane-Propane News 22,* 29 (1960) Aug. (3 pp.)

ICC specification MC 330 covers the design and construction of steel cargo tanks. It requires that the vessel be fabricated in accordance with the ASME Code, generally the 1959 edition. ICC specification MC 330 states that fittings and valves should be "adequately protected" by a housing. NFPA Pamphlet 58 requires valves to be "safeguarded against physical damage." In analyzing valves and piping design, three factors are important: operation, safety and cost.

Operator's Handbook for Gasoline Plants. Manufacturing Dept., Tennessee Oil Refining Co. *Petrol. Refiner 39,* 157 (1960) July (4 pp.)

Every natural gasoline plant has installed facilities to help prevent explosions and combat fires. They are not necessarily the same for each plant, but they all are installed for the same purpose—to prevent injury to personnel and damage to plant facilities. The cause of fires is best illustrated by the fire triangle. The sides of the triangle are fuel, oxygen and heat. To prevent, or to extinguish any fire, all that is necessary is to remove any one of the three ingredients.

Space Heaters

Fundamental Gas Heating Service. J. Lee. *Gas Heat and Comfort Cooling 11,* 30 (1960) July (6 pp.)

Review of the basic elements of gas heating service, including burner flame observation, flue analysis, provision for air supply, venting, unit location, controls and manual operation and liabilities.

Underground Storage

LPG Salt-Cavern Storage Suit May Be Settled. *Oil Gas J. 58,* 60 (1960) July 18.

Out-of-court settlement of the Sid Richardson patent case, involving withdrawals of LPG from salt cavern underground storage, appears possible. Trial of a suit, asking four companies to pay ⅛ cent/gal royalty for LPG taken from storage in Carson and Hockley counties, Texas, since 1957, has been stricken from the court docket and postponed indefinitely.

2. ENERGY SUPPLY AND ECONOMICS

Fuel Competition

Fuel-Oil Men Are Now Fighting Back. J. P. O'Donnell. *Oil Gas J. 58,* 126 (1960) July 25 (4 pp.)

Fueloil marketers are embarked on a program designed to 1) regain lost business, 2) retain the *status quo* in some areas, and 3) retard the progress of gas in other areas. Expenditures of $3,000,000 are earmarked for advertising. Research has produced better equipment and improved quality. The business is important to more than just the heating-oil marketers. One economist observed that when oil loses much of the growth of this market to gas, the impact is substantial. Allowable schedules, crude oil production rates, refinery rates, pipeline movements and tanker shipments all are affected.

Petrochemicals

Plant Construction at Midyear. Emphasis Is on Petrochemical Expansion. R. B. Bizal. *Oil Gas J. 58,* 185 (1960) July 25 (6 pp.)

New survey on refining, field processing and petrochem construction shows that of the more than 200 projects under way or planned in the U.S. and Canada, 122 of them are petrochemical plants. This includes 106 in the U.S. and 16 in Canada. A complete rundown of domestic plant construction is given.

Petroleum

Petroleum Thinking for the Sixties. P. Kelton. *Pipe Line News 32,* 32 (1960) July (6 pp.)

Separateness of thought, says author, i.e., individual judgments made by individual segments of oil and gas industry, is a source of embarrassment to the industry. For example, only recently did industry become aware of the producer gas price problem. The search today is for a new way of thinking. Author points out some of the factors that should align the policies and politics of each industry segment in the next decade.

Which Holds the High Cards—North Africa or Middle East. F. E. Wellings. *Oil Gas J. 58,* 80 (1960) July 11 (6 pp.)

In 1959, the Middle East's increase in production over 1958 was 7.7%, almost the same as the world's increase, 7.6%, and it also maintained its share of world produc-

tion, 23%. The next two years' exports from the Sahara can probably be absorbed in France, but when Libya comes on production, North African capacity might amount to 50 million tons per year by 1965 and would compete with the Middle East—and the USSR—for the European market. Comparisons of fields, geology, production and growth are outlined.

Louisiana Operators Ask—Why Drill for Off-Shore Oil? D. E. Lambert. *World Oil 151,* 86 (1960) July (4 pp.)

Operators are wondering how far beyond 1960 it will be before they start breaking even. Reason: Late in June, Louisiana's Conservation Commissioner Ashton Mouton issued a temporary written order retroactive to June 7, which said in effect: 1) Allowables will be granted for multiple completed oil zones that are completed in existing wells within the same fault block. However, any new zones will not be allowed to produce unless they are completed singly; 2) When a gas well is completed with one or more oil sands, which has not previously been approved, only one oil sand will receive an allowable. According to Thomas M. Winfiele, chief engineer for the Louisiana Conservation Department. "The purpose of this limitation is to temporarily minimize the number of oil well completions during this time of short market, and one of the ways of doing this is to not allow any new pools to be multiple-completed with any other pools." One thing is certain, the recent trend toward increased offshore oil field development will slow to a crawl.

Oil Conservation in the Classroom . . . A Study in Applied Political Economy. W. F. Lovejoy. *Oil Gas J. 59,* 177 (1960) July 25 (4 pp.)

In academic circles, the oil industry is too often approached from separate exclusive directions: economic, engineering, legal and political. In a recent seminar, these interrelated mutually dependent factors were considered together. The results: a broader appreciation of the many aspects of conservation.

Standard of Jersey's New Plan for Realignment. *Business Week,* (No. 1614) 44 (1960) Aug. 6 (6 pp.)

World oil glut is forcing Jersey Standard to revamp its organizational structure, consolidate its operations and reduce costs. Some of the modifications include: headquarters "contacts" with its more than 200 affiliated companies are now set up regionally throughout the world rather than by individual companies; a new high-level committee, the Board Advisory Committee on Investments, is screening capital spending projects and is supposed to help the board work out new investment policies.

Petroleum Refining

Japan's Refining—640,000 b/d This Year—Continues Its Steep Rise. M. Ishii. *World Petrol. 31,* 70 (1960) July 15 (3 pp.)

Since 1945, Japan's petroleum demand has risen from 1.6 million barrels to an estimated 160 million barrels. Before the war, the peak demand for oil products was the 31.5 million barrel figure of 1937. In 1952, it was 34 million barrels; in 1960, the demand had increased about 500%. Increased demand was concentrated in three large cities—Tokyo, Osaka and Nagoya; the remainder, about 40%, was distributed throughout Japan.

The World's Processing Plants. *World Petrol. 31,* 100 (1960) July 15 (14 pp.); **The World's Petrochemical Plants.** *Ibid.,* 122 (1960) July 15 (9 pp.)

Complete directory of the world's petroleum refineries and world's petrochemical plants is presented. Included are all facilities—presently operating, planned, or under construction—in all countries outside the USA but including the USSR and other communist nations where reliable information was available.

World Processing Continues Rise. W. C. Uhl. *World Petrol. 31,* 56 (1960) July 15 (4 pp.)

World's total refining capacity (23.43 million bbl/day in 1960) will rise 20.8% by 1963 to 28.30 million bbl/day. Construction in the Eastern Hemisphere continues to account for a major portion of the increase. Studies indicate an expansion of almost 29% in comparison with about 11% in the Western Hemisphere. Expansion in the Western Hemisphere will be some 1,525,700 bbl/day, from a 1960 level of 13,727,700 bbl/day to an estimated 1963 level of 15,253,400 bbl/day. In the east, capacity will rise from 7,050,400 bbl/day this year to 9,089,100 bbl/day in 1963, an increase of 2,028,700 bbl/day.

Shale Oil

Oil Shale Recovery and Refining in Sweden. *Erdol und Kohle 13,* 285 (1960) Apr. (4 pp. German text.)

Fairly detailed account is given of the oil shale processing industry of Svenska Skifferolje AB near Kvarntorp. Both retorting of mined shale and electrothermal gasification *in situ* are practiced on the 1.7-billion ton, 7-8 layer shale reserve. Descriptions of retorting and refining as well as yield data of the 120,000 m^3/yr of crude installation are discussed.

Solar Energy

Apparatus for Utilization of Solar Energy. L. E. Hutchings (assigned to Pure Oil Co.) U.S. 2,942,411 (1960) June 28.

Solar energy may be accumulated and stored for use when sunlight is not available by the system claimed. Water from a condensate reservoir is heat exchanged and converted to steam in a solar boiler of any design, the steam driving a turbine and gas compressor, and the steam condensate returning to the reservoir. Gas, such as methane, from a low-pressure (50 psia) underground reservoir is fed to the turbine-driven compressor and compressed to 500 psia. Part of the latter high-pressure gas is reserved for periods when solar energy is not available. The remainder drives an isothermal air-motor to generate power. Underground reservoirs may be used for both gas and water.

Solar Heat Exchangers. J. A. Duffie, G. O. G. Löf and E. M. A. Salam. *Chem. Eng. Progress 56,* 63 (1960) July (5 pp.)

Energy of the total available solar spectrum, including the near infrared, is useful in thermal processes. All thermal processes require solar heat exchangers to intercept the radiation and convert it for the purpose at hand. Article is concerned with the analysis of energy balances for these exchangers.

Tar Sands

Mining and Ore Disposal Complicate Tar Sands Development. *Petrol. Week 11,* 20 (1960) Aug. 5 (2 pp.)

Materials-handling aspects of mining and the disposal of tailings may prove tough barriers to economic development of Alberta's Athbasca for sands. Results of the research program being conducted by the four company team in the Mildred Lake region show that further study is necessary to solve the problems.

Thermoelectricity

Theory of Thermoelectric Refrigeration. R. Dahlberg. *Z. agnew. Phys. 10,* 361 (1958) Aug. (8 pp. German text.) (From *Appl. Mech. Rev. 13,* 510 (1960) July.)

Theoretical development during this century is briefly reviewed, then performance of multistage thermopiles (temperature differences in series) is considered with graphical indications of the gains in performance expected. Finally, the paper reviews possibilities of further advances by manipulation of the ratio of conductivities of heat and electricity, using the tunnel effect in semiconductor. Author points out that if the properties of electron gases could be employed, the use of thermoelectric effects for both reversed and direct "heat engines" would become competitive.

D. Wilson

3. NATURAL GAS AND PETROLEUM PRODUCTION

Drilling

How High Rotary Speed Shortens Bit Life, Increases Drilling Costs. R. A. Cunningham. *Oil Gas J. 58,* 91 (1960) July 11 (6 pp.)

Rock-bit footage goes down and costs go up at high rotary speeds. As a result, the best chance of reducing drilling costs is not related to high rotary speeds. A combination of proper weight on bit with moderate rotary r.p.m. and good bottom-hole cleaning is more reliable.

Percussion Drilling Tool Increases Bit Footage. W. E. Liljestrand. *Petrol. Eng. 32,* B-21 (1960) July (4 pp.)

Answer to question, "Is bit life really longer when used with a hammer drill?" is a definite yes. Many bits have been run on the hammer drill and compared with bits used in conventional air rotary drilling. In most of the runs, the bit life on the hammer drill was longer, in some the life was the same, and almost none was it less. By May 15, 1960, 150 bits had been used on the hammer drill in 40 wells drilling over 55,000 ft. Up to 31,490 ft. of hammer drill hole using 71 bits had been drilled and could be compared with 18,675 ft. of conventional air rotary drilling. This was done in 20 wells.

What Is the Low Bid? R. L. Parker. *Drilling 21,* 50 (1960) July (7 pp.)

Author's belief is that drilling costs can be reduced by 50% in five years if operators can adjust their thinking; that is, there should be 25-50% more per day income per rig. This means an average income increase of $1500-$2000 per day. Author says that present policies of fighting nickels and dimes per foot on drilling prices is preventing the solution of reducing development costs by 40-50%. The contractors, he contends, are so financially weakened that they cannot experiment on their own.

Drilling Muds

Low-Solids Mud Resists Contamination. H. E. Mallory, W. E. Holman and R. J. Duran. *Petrol. Eng. 32,* B-25 (1960) July (6 pp.)

It has been accepted by the drilling industry that low solids muds used in conjunction with proper drill collar weights, rpm and hydraulics, offer better rates on penetration. Low solids fresh water muds contain minimum amounts of bentonites and low specific gravity drill solids combined with high or low viscosity grades of sodium carboxymethylcellulose (NaCMC). Recognizing the distinct advantages that could be gained by making a low solids mud in salt or highly contaminated water that would offer all of the advantages gained by NaCMC in fresh water, authors have, for the past three years, participated in a development program to produce a colloid that would afford all of these desirable qualities. The guar gum meets more of the basic requirements, and appears to lend itself to modification to meet those requirements it does not fulfill in its natural form.

Exploration

Ouachita Mountains Do Have Oil and Gas Potential. P. A. Chenoweth. *World Oil 151,* 94 (1960) Aug. 1 (4 pp.)

Oil and gas are present within the Ouachita Mountains (Okla.) province. The degree of metamorphism to which the sediments have been subjected has been exaggerated in the past. The high carbon ratio arguments previously used to condemn Ouachita prospects are inaccurate and their significance, if any, is not yet resolved. Author doubts that structural complexities condemn the area.

Logging

Modern Well Completion Series. Part 7. New Developments in Nuclear Logging. J. C. Stick, Jr. *Petrol. Eng. 32,* B-31 (1960) July (9 pp.)

The neutron curve was found to respond primarily to the hydrogen present in the formation. Nuclear logs now range from very precise measurements made with

highly specialized neutron generators to rather low quality gamma ray measurements made directly with casing perforating equipment to enable the perforations to be located precisely. The object of this discussion is to describe briefly how radioactivity logs are made and to review the current status of this form of logging.

Sonic Log Evaluates Morrow Sand. F. S. Millard. *Petrol. Eng. 32,* B-29 (1960) Aug. (6 pp.)

Empirical curves which relate weighted core porosity and formation velocity or transit time have been developed for the relatively shale-free Morrow sand in western Oklahoma. The effect of fluid and residual gas in the invaded zone has been investigated and is considered in the empirical curves. The comparison of formation resistivity and transit time using specially-designed graph paper in many instances provides a rapid method of formation evaluation. Some examples showing the application, advantages and limitations of the procedures are presented.

Recycling

Field Histories Show Benefits of Gas and Water-Injection Projects in Eastern Venezuela. L. A. Ramsey. *J. Petrol. Tech. 32,* 33 (1960) July (4 pp.)

Article reviews increased ultimate recovery, lowered artificial-lift costs, and, in the case of gas injection, lowered treating costs and the conservation of natural gas which have resulted from pressure and maintenance depletion of appropriate Venezuela reservoirs since 1948. Discussion of reservoirs in Central Oficina and OG-202 fields is included.

Reservoir Engineering

Fluid Flow in Petroleum Reservoirs. Part III. Effect of Fluid-Fluid Interfacial Boundary Condition. W. Rose. (Urbana, Illinois: Ill. State Geological Survey, Circ. 291, 1960.)

Relative permeabilities greater than unity are predicted (for a reason different from that developed in Part I of this series), and it is shown that Darcy's Law does not accurately describe mixture flow phenomena in view of the non-zero velocity boundary condition that sometimes exists at the fluid-fluid interfacial boundaries. These indications are not to be gathered from examining available experimental data on relative permeability, but explanations are given to reconcile the discrepancy. The analyses are based on mathematical models of reservoir rock porous media system. To the extent that the models and the reservoir prototype correspond, valid inferences that are important to an understanding of the mechanics of oil recovery processes can be expected.

Secondary Recovery

Operating Conditions Can Be a Practical Guide to Miscible-Flood Design. W. E. Brigham and J. N. Dew. *Oil Gas J. 58,* 87 (1960) July 18 (7 pp.)

Design of miscible-flood systems depends on these factors: 1) miscible conditions must be maintained to prevent drastic reduction of recoveries; 2) recovery efficiency should be calculated in a manner similar to water flooding; 3) proper slug size seems to be 5% of hydrocarbon pore volume; 4) miscible process appears most attractive for low-viscosity oil in tight or water-sensitive reservoirs; and 5) economics must be compared with other secondary recovery techniques.

How to Recover More Flood Oil Faster. *Petrol. Week 11,* 25 (1960) July 15 (3 pp.)

Orco Process—a secondary recovery method based on injection of carbonated water—has been established as an economic success with its first commercial application. It involves the simultaneous injection of metered water down the tubing-casing annulus and carbon dioxide gas down a macaroni string. The CO_2 mixes with the water at the pay face to form carbonated water, which then enters the producing formation under pressure. Oil Recovery Corp.'s 240 acre K and S flood project, in Washington County, Okla., was started in early 1958. It has been indicated that the project will result in an ultimate recovery of 1,350,000 bbl of oil. This figure represents an additional oil return of 364,000 bbl, or 37% more than would have been recovered with conventional waterflood.

Well Practice

Field-Constructed Gas Anchors can Save Money. C. J. Merryman. *World Oil 151,* 75 (1960) Aug. 1 (4 pp.)

Majority of pumping well gas troubles is caused by free gas in the well bore, gas trapped in the fluid column and gas being liberated from solution by either agitation or pressure changes. The ideal method of eliminating gas interference would be to separate the free gas from the fluid and allow it to be vented through the casing annulus. The gas anchor serves this purpose by being a gas-fluid separator that uses gravity and agitation to separate as much gas as possible from the fluid prior to entering the pump.

New Cement Additive Cuts Water Loss. E. McGhee. *Oil Gas J. 58,* 119 (1960) Aug. 1 (3 pp.)

Oil-well cement can now, for the first time, have a low water loss without harmful side effects caused by conventional water-loss reducers because of a new organic chemical. Small quantities of the material (1.0 to 1.5%) in a cement slurry can cut water loss below 50 cc. per 30 minutes. The polymer ("Flac") is a dry powder which can be easily handled like other cement additives; it is water-soluble and has good thermal stability.

Sunray Completes World's First Sextuple Well. P. E. Robinson and R. W. Scott. *World Oil 151,* 79 (1960) July (7 pp.)

Sunray Mid-Continent Oil Company has completed the oil industry's first small diameter sextuple well in North Laward field, Jackson County, Texas. The miniaturized well completion method was used to complete J. A. Graves 6 as a six-zone producer, since known reserves of the six potential gas producing zones would not support the cost of drilling conventional-size wells.

Unique Gas Lift Hookup Used to Dewater Gas Wells. J. A. Ziser. *World Oil 151,* 92 (1960) July (3 pp.)

Gas well dewatering technique discussed is unique in that no gas is vented to the atmosphere when lifting water. The only gas used (about 4 MCF/day) is that required for fuel for the compressor engine. Prior to installing the closed rotative system, 94 MCF/day was used to jet water from the well through a 1¼-in. syphon string. This gas was vented and wasted. Thus, approximately 90 MCF/day is being saved.

4. GAS CONDITIONING AND LPG RECOVERY

Adsorption

Practical Way to Sweeten Natural Gas. J. C. Fails and W. D. Harris. *Oil Gas J. 58,* 86 (1960) July 11 (5 pp.)

Molecular sieves No. 5-A or No. 13-A appear to be the most promising material to use in a selective adsorption process. The process at present is not a universally desirable system. For example, heavy ends may tend to plug the molecular sieves. However, it appears to have definite economic advantages: 1) where the sour gas reservoir has high CO_2 content, 2) where delivery is large enough, and 3) in remote areas where automation is desirable.

Dehydration

The Dehydration of Gas in Underground Storage at Lussagnet. L. Socrate. (Assoc. Tech. de l'Ind. du Gaz en France, 1960 Congress; 6 pp, French text.)

The sandy aquiferous structure of Lussagnet was studied as a possible site for the storage of purified natural gas from Lacq. By 1958, a large amount of gas was being stored there. To prevent the hydrate formation in the field wet gas collector, a preliminary glycol dehyration is used. The final dehydration is carried out in a two-stage contact process, by fine glycol spraying in a relatively small diameter collector. This is an inexpensive and versatile solution for treating a large amount of gas.

Hydrocarbon Removal

Gasoline Extraction by Cryogenic Methods. J. Bordas and J-B. Delorge. (Assoc. Tech. de l'Ind. du Gaz en France, 1960 Congress; 11 pp, French text.)

Treatment of natural gas from Lacq, which will require five separate units within a year, is currently carried out in three units. Apart from their capacity, these five units differ only in the solution adopted for elimination of the gasoline. The input gas, which is refrigerated by the gasoline-free gas emerging from the plant, is expanded from 63 to 45 kg, while extra frigories are provided by propane- and ethane-operated refrigerating equipment. Paper describes first the circuit followed by the input gas up to the point where the three hydrocarbon streams are produced (high-pressure gas, low-pressure gas and the mixture of heavier hydrocarbons to be fractionated) and, second, the cascade-type refrigeration circuit using compressors and exchangers (ethane and propane type coolants).

12,600 bbl. of Liquids Daily from 169 MMCF of Wet Gas. H. C. Bozeman. *Oil Gas J. 58,* 131 (1960) Aug. 1 (2 pp.)

Features of Texas Eastern Transmission Co.'s Rayne, La., plant: construction costs were lowered by producing only two products—a stabilized condensate stream and a propane-butane-condensate mixture. Texas Eastern owns the estimated 1 trillion CF of gas reserves at Rayne field. However, the liquids are owned by Continental Oil Co., General Crude Oil Co., M. H. Marr, and Sun Oil Co. Two stages of separation are made before the gas is contacted with absorption oil. No recompression is necessary to deliver the residue gas to the pipeline after hydrocarbon removal. Power recovery turbines drive cooling-water pumps and a process pump.

Operation of a Dry-Desiccant Type Hydrocarbon Recovery Unit. Q. S. Drake and E. R. Dawson. *J. Petrol. Tech. 12,* 19 (1960) July (3 pp.)

Description of a dry-desiccant type hydrocarbon recovery and dehydration unit which, in a field south of Houston, Texas, is expected to pay out in less than two years, before taxes and depreciation. Article explains method of operation of the unit.

Hydrogen Sulfide Removal

The Evolution of Hydrogen Sulfide. J. Dwyer, J. V. Latham, H. F. Taylor and C. E. Young. *Gas World 152,* (1960) July 9 (5 pp.)

It is shown that if a prepared oxide contains free iron and sulphur, it is to be expected that in a stream of N_2, H_2S will be evolved unless the mixture is maintained in an alkaline condition, in which case little or no evolution occurs. The experimental method is described and a theoretical explanation is offered for the observed results. Measurements of oxygen absorption by oxide mixtures containing free iron showed that this absorption is strongly counteracted by the presence of free lime.

Method of Removing Hydrogen Sulfide from Gaseous Mixtures. G. Giammarco (assigned to S.p.A. "Vetrocoke".) U.S. 2,943,910 (1960) July 5.

Method of removing hydrogen sulfide (and carbon dioxide) from gaseous mixtures is claimed which comprises scrubbing the mixture with an aqueous solution of alkaline arsenite and arsenate. The improvement claimed is in the regeneration of the sulfided solution. In a part of this, by a pressure digestion step in the presence of excess arsenate, the thioarsenite is converted to monothioarsenate and arsenite. The monothioarsenate is further converted to arsenite and sulfur by acidification with CO_2 under pressure. Solid sulfur is removed and the filtered solution is added to the remainder of the fouled solution and is heated to 50-90°C, whereby CO_2 is boiled out (for further use in acidification). The solution is then blown with air in a second

contact tower, whereby residual CO_2 is removed and the arsenite is oxidized to arsenate. The concurring balance of arsenate-thioarsenite and the *p*H value due to CO_2 results in a continuous removal of H_2S and recovery of elemental sulfur.

Purification of the Residual Gas at the Lacq Sulphur Plants. P. Bapseres and M. Comte. (Assoc. Tech. de l'Ind. du Gas en France, 1960 Congress; 10 pp, French text.)

Description of the method of ammonia scrubbing of the residual gases which, at Lacq, is performed upstream of the incinerator. The function of the incinerator is to transform the residual hydrogen sulfide into sulfur dioxide and to raise the temperature of the smoke to about 500°C in order to facilitate its dispersal into the atmosphere. The method of scrubbing used makes it possible to reduce sulfur losses and pollution hazards in the proportion of 70-90%. Under certain specific processing conditions, the scrubbing solutions can be quantitatively converted into ammonium sulfate and sulfur.

Separators

Hydrocarbon Hydrate Separation Process and Separation Unit Therefor. S. A. Wilson (assigned to National Tank Co.) U.S. 2,943,124 (1960) June 28.

Gas at well temperature and pressure is passed through a coil member of a second baffled vessel and into a dispersing nozzle in a first baffled vessel, where its slight temperature reduction will cause precipitation of some water, condensate, paraffins and mud. Gas from the first vessel is expanded through a choke into the second vessel where the great cooling effect forms hydrates. These are melted and decomposed by the hot inlet coil, and the water and heavy hydrocarbons fall to the base of the vessel where they are drained by level regulating valves, while gas leaves the gas space above the coil.

5. NATURAL GAS TRANSMISSION

Automation

Automation—The Manufacturer's View. W. F. Haley. *Gas Age 126,* 23 (1960) July 7 (5 pp.)

Many problems have not been solved as far as setting forth complete equations for systematic control of a complete gas system. However, the state of the art has progressed to a point where integrated centralized control equipment is available for controlling a complete pipeline system.

Automation—Operator's View. H. O. Porter. *Gas Age 126,* 30 (1960) July 7 (5 pp.)

In the absence of factory-installed automated equipment, it has been necessary for the user to approach automation on the basis of his own specific operating conditions. Two key factors in a user-designed approach to automation are type of equipment and employee relations. Latter tends to gear the program to employee turnover by retirement and/or leaving. The approach used by Cities Service Gas Co. is described.

Compressors

Operating Characteristics of Centrifugal Compressors. C. Taylor. *Gas 36,* 93 (1960) July (8 pp.)

Gas industry regards the centrifugal compressor as one of the major factors in providing low-cost natural gas service throughout the country. While the centrifugal compressor has found its place in pipeline service, the industry has not yet determined what single prime mover is best suited for mating with the compressor. The industry now recognizes this basic fact: the centrifugal compressor, when mated with the correct prime mover for a given application, is a highly desirable, reliable, and economical compressor unit operation. Principles of design, flow and application are discussed.

Fluid Flow

Adjustable Flow Meter. V. L. Streeter (assigned to the Dole Valve Co.) U.S. 2,941,401 (1960) June 21.

Adjustable flowmeter is claimed, in which an orifice with a profiled throat has a movable central disc, or valve-like head, positioned centrally to provide a flow area which varies as the square root of the pressure head. The valve disc is carried on springs which provide a nonlinear support and cause a logarithmic increase of throat area with valve head movement. This results in a linear variation in pressure drop with flow.

Flow Calculation Manual for Natural Gas Transmission Lines Is Under Development. R. T. Ellington and W. R. Staats. *Pipe Line Ind. 13,* 26 (1960) July (6 pp.)

Knowledge of the flow behavior of natural gas transmission lines is now sufficiently complete that a basic equation can be recommended that takes into account the full range of the variables known to be important. It especially includes the effective roughness of the pipe wall. This equation has been put in a form similar to that of the orifice flow equation so that sets of tables can be employed to facilitate calculations such as those in using the AGA Orifice Meter Report No. 3.

Metering

Fluid Mass Flow—and the Story of the Meter Which Measures It. C. M. Halsell, J. B. Stewart and M. R. Engles, Jr. *Pipe Line News 32,* 23 (1960) July (7 pp.)

Basic theory of mass flowmetering is described along with the function and operation of the mass flowmeter. Most important, article is designed to answer questions about the application of the flowmeter to measurement practices in the natural gas industry. To accomplish the latter, the question and answer method is used.

Pipeline Construction

Bellhole Construction. M. E. Fuller. *Pipeline Eng 7,* D-15 (1960) July (4 pp.); **Bellholed Pipeline Brings Additional Gas to Southern California.** J. F. Ebdon. *Gas 36,* 105 (1960) Aug. (16 pp.)

Pacific Lighting Gas Supply Company, in December 1959, took bids for construction of 116 miles of 34-in. pipeline in the Mojave Desert between the Colorado River and Newberry, Calif. The new line is a link in the facilities to deliver gas from Transwestern Pipeline Company to Southern California. Factors influencing bellhole construction were: 1) lower cost, 2) better coating quality, 3) less pipe stress, 4) less manpower, and 5) fewer shutdowns due to high winds.

Contracts Let for Big Gas Line. *Oil Gas J. 58,* 72 (1960) July 11.

Eleven contracts have been awarded by Midwestern Gas Transmission Co. to build its $52 million line that will move Western Canada gas into the upper U. S. Middle West by November. Approximately 200 MMCF/day of Alberta gas will move into Midwestern's line from those of Trans-Canada Pipe Lines, Ltd., at a point on the international border south of Winnipeg.

Inspection Practices at Mills Insure Quality of Delivered Pipe. N. K. Senatoroff. *Gas 36,* 108 (1960) July (3 pp.)

With a backlog of orders and with mills working at three-shift capacity, plus the critical chemistry of high-strength grade steel, inspection procedures at the mill should cover three phases: 1) preliminary exploratory inspection of fabricating facilities and quality control instrumentation, 2) material specimen control tests, and 3) inspection of the finished line pipe.

The Second Saharan Pipeline: Zarzaitine-La Skhirra. F. Korn. *Petrol. 23,* 257 (1960) July (4 pp.)

To transport oil discovered first by CREPS at Edjeleh, and later in other areas, to the coast, the Compagnie des Transports par Pipelines au Sahara (TRAPSA) in 1959 began construction of a 24-in., 465-mile pipeline. This will be able to handle, beginning in October 1960, a throughput of 7 million tons/year. Important technical and economic factors necessitated the termination of this pipeline in the Gulf of Gabes.

Pipeline Operations

CIG's New Control System: How It Works. H. Saye. *Pipeline Eng. 32,* D-21 (1960) July (4 pp.)

Pressure control, the basis for operating a natural gas transmission system, is a complex thing when the system's capacity is large. It requires much computation and the consideration of many variables such as the nature of the gas itself, the Btu content, the station altitude, the number of compressors on the line, their speed and compression ratio, line pack, and fluctuating demand. Article discusses in detail the equipment installed to handle these variables.

New Variable Pipeline Scraper Saves $200,000. P. Reed. *Oil Gas J. 58,* 94 (1960) July 18 (2 pp.)

Unusual feature of new tool provides for holding cleaning knives firm against the interior of the pipe wall. More than $200,000 in capital expenditures has been saved in less than two years since the new scraper was introduced. Outline of unusual features and history of development are included.

Pipe-Line Exploration. S. A. Scherbatskoy. U.S. 2,940,302 (1960) June 14.

Method and apparatus are claimed for the internal exploration of a pipeline carrying a flowing fluid. This consists of a carriage moved by the force of the flowing fluid, either by a pressure-driven pig or by a fluid-rotated propeller driving a generator-motor. The carriage may carry a housing containing suitable transmitting instruments (or tape recorders) which give signals denoting the position of the apparatus, fluid pressure, pipe wall thickness, corrosion areas and leakage points. Such signals may be generated by ultrasonic, electromagnetic or radioactive isotopic methods, and detected by outside or surface receivers.

Pipeline Systems

Trace 7-Mile Underwater Sulphur Piping System with 320 F Water. C. M. Cockrell. *Heating, Piping and Air Conditioning 32,* 101 (1960) Aug. (4 pp.)

World's first offshore sulfur mine is capable of producing 4500 tons of sulfur daily through an underwater piping system. Buried 5 ft in the ocean floor, this seven-mile concentric system comprises a 6-in. internal pipeline surrounded by a trace line conveying 320 F water to keep the sulfur from freezing (at 240 F) enroute from the mine to a barge loading point. Article briefly discusses the system's design features and reviews some of the problems encountered in its development.

Welding

Pressure Welding for Pipelines. R. L. Koppenhofer, W. J. Lewis, G. E. Faulkner, P. J. Reippel and H. C. Cook. *Oil Gas J. 58,* 114 (1960) July 11 (5 pp.)

In the construction of modern gas and petroleum pipelines the rate of progress overland is governed by the speed with which the separate pipe lengths can be joined together. Developments in ditching, pipe-handling, and coating equipment have accelerated the operation of the pipeline spread; pipe could be laid many times faster if an effective means could be found to join the pipe at this higher rate. An automatic method which in the past enjoyed moderate success in the field was the pressure welding process using oxy-acetylene gas burners to supply the heat. This type of weld is basically a "forge weld" similar to those made by the old blacksmith. The gas-fired pressure welding of pipe presented several disadvantages; in particular: 1) lack of adequate control of metal-forging temperature, 2) too long a heating time, and 3) too broad a heat pattern. Tests of induction-heated pressure welding are discussed.

Submerged Arc Pipe Welding: Why? With What? How? *Heating, Piping and Air Conditioning 32,* 114 (1960) Aug. (4 pp.)

Reducing labor costs and increasing weld quality are the two main reasons for welding pipe automatically. The higher deposition rate of automatic submerged arc weld-

ing obtained by raising the welding current permits increased welding speed. This speed increase, usually two to four times that of hand welding, reduces labor cost. Fewer stops and starts are directly responsible for improved weld quality. Heavier welds are run continuously, bead after bead without stopping. Due to the continuous deposition of high quality weld metal, the submerged arc process produces X-ray quality welds.

6. GAS AND LPG STORAGE

LPG

Design and Operating Problems Involved in the Marine Transportation of LP-Gas. J. T. Kirk, Jr. and R. H. Rogers. *LP-Gas 20,* 30 (1960) Aug. (5 pp.)

Evaluation of many factors involved in marine transportation of LPG, if properly made, eliminates major problems. Studies of vessel costs, taking into consideration such factors and based on normal operating and terminal conditions, indicate that lowest cost LPG transportation is obtained from vessels designed for low temperature and atmospheric pressure operation and should be combination LPG/bulk oil carriers whenever possible.

Methane Liquefaction

Apparatus for Transporting, Storing and Using Natural Gas. W. L. Morrison (assigned to Constock Liquid Methane Corp.) U.S. 2,940,268 (1960) June 14.

Two-stage expansion system is claimed for a barge-mounted natural gas liquefaction plant. High-pressure gas from a well is expanded to reduce temperature, the condensate is withdrawn, and cooled gas is used in heat exchange with raw gas. After amine scrubbing and dehydration, the cooled gas is expanded in an expansion turbine and liquefied methane is withdrawn to balsa-insulated tanks on the vessel

Expansible Container for Fluids at Low Temperature. W. L. Benson and N. C. Dahl (assigned to Constock Liquid Methane Corp.) U.S. 2,944,693 (1960) July 12.

Storage tank for low-boiling liquids such as liquefied methane is claimed in which the inner containing metal tank is kept pressed against an outer insulating coating. Each wall of the tank moves outward under pressure by virtue of a cylindrical expansion joint at each edge of the rectangular tank. This joint is deformed from cylindrical shape under hydraulic pressure of liquid or under gas pressure. The bottom and top edges may be similarly joined.

Expansible Container for Low-Temperature Fluid. A. J. Farrell and A. Pastuhov (assigned to Constock Liquid Methane Corp.) U.S. 2,944,692 (1960) July 12.

Tank for storing and shipping extreme low-temperature liquids, such as liquefied methane, is claimed which comprises an external insulating wall against which the inner thin metal tank is tightly held. This is accomplished in spite of contraction of cold tank metal by making the wall very thin, of rectangular shape, and forming each tank edge of a bellows member. The bellows may be supported by welding inner bellows edges to an internal vertical frame which remains rigid while the bellows-held wall moves out under liquid or gas pressure and is partially supported by the insulation. An outer metal tank surrounding the insulation may be added.

How Low for Natural Gas Processing Temperatures. B. C. Barnes, C. P. Stanley, G. E. Hays, W. W. Bodle, H. W. Barber, and O. C. Baker. *Petro and Chem Eng 32,* C-12 (1960) July (7 pp.)

Low temperature operations for liquid-gas separation and absorption steps in natural gas processing facilities are gaining wide acceptance. New process designs frequently specify that these operations will be carried out at temperatures between 40°F and −20°F. In general, the operation of liquid recovery facilities at low temperatures will improve the efficiency of condensation of the heavier components in the feed gas. Generally the increase in recovery will be obtained with a higher degree of selectivity so that it is easier to obtain liquid products of the required purity. If low temperature processing is profitable, how low an operating temperature should be used? This question is answered by evaluating investment and operating expenses and income for process facilities designed to operate at various low temperature levels. The trend to refrigerated design and its advantages are emphasized by the several authors. Bodle discusses possible extension to liquefied methane, helium recovery and nitrogen removal. Barber points to increasing demand for lighter NGL, especially for petrochemicals. Baker emphasizes the need for reliable thermodynamic design data and reviews NGAA's concern with lack of enthalpy data and the cost of overdesign to the industry. He reviews the economics of a $300,000 eight-year research program.

Low Temperature Fractionation of Natural Gas Components. S. B. Jackson (assigned to the Fluor Corp., Ltd.) U.S. 2,940,271 (1960) June 14.

Process for the separation of methane, nitrogen and helium is claimed. This comprises cooling to low subzero temperatures and feeding cooled gas to a vertical fractionating zone to partially condense the methane and remove a nitrogen-methane overhead of 10-50% CH_4. An essentially methane stream from the bottom of the fractionator is passed through the heat exchange zone, expanded and used as a condensing-zone coolant, heat exchanged in the first-mentioned zone to precool, and then compressed, cooled and returned to the fractionator. For helium separation, the fractionator overhead is condensed and separated to leave an He-rich gas, which is heat exchanged, condensed and separated in the preceding exchanger passes to obtain first, liquid CH_4, and second, liquid N_2.

Method and Apparatus for Preparing Natural Gas for Liquefaction. W. L. Morrison (assigned to Constock Liquid Methane Corp.) U.S. 2,941,374 (1960) June 21.

In a natural gas liquefaction process, the high well pressure is expanded in a primary turbine doing external work, removing condensibles, raising the pressure with the primary turbine power and cooling by heat exchange. The impurities, such as acid gases, are then removed by amine and glycol contactors and the gas is expanded in a second main turbine to liquefy part of the gas.

Prestressed Concrete for LP-Gas Storage. H. E. Thomas and R. J. Sweitzer. *Gas Age 126,* 19 (1960) July 7 (4 pp.)

Real answer to frequently operated large volume storage is a container which automatically maintains constant, low temperatures. Underground storage permits use of a storage vessel with lesser design working pressure than for conventional tanks. Requirements are well within capacities of prestressed concrete embedded cylinder pipe, as indicated by satisfactory performances in the field with experimental installations.

Some Results of Experimental Research into the Storage of Liquefied Natural Gas. J. Besnard and R. Vincent. (Assoc. Tech. de l'Ind. du Gaz en France, 1960 Congress; 12 pp, French text.)

Results are presented of a study of the problem of storing liquefied natural gas, undertaken at the D.E. T.N. (Direction des Etudes et Techniques Nouvelles du Gaz de France). While the study included laboratory, semi-industrial and industrial phases, only the results of the first phase are reported.

Storage Vessels for Liquefied Gases. W. O. Keeping (assigned to The British Oxygen Co. Ltd.) U.S. 2,940,631 (1960) June 14.

Evaporation losses of liquefied gases, such as oxygen and nitrogen, are reduced by storage in a double-walled vessel. Heat leakage into the vessel is reduced by making the filling and venting lines of double-walled construction, with the outer wall of the line joined to the inner wall of the vessel. The space between inner and outer walls of both the vessel and the entering lines is filled with insulating powder, and the space is evacuated. The filling and vapor lines, with their jackets, are made long, extending through the stored liquid to the wall opposite their point of attachment to the outer shell, so that the line is maintained at the temperature of the liquid. The jackets may contain aluminum powder as a reflectant to reduce heat radiation into the tank.

Storage

Conservation Arrangement. C. A. Basore and W. L. Barham (assigned to Union Tank Car Co.) U.S. 2,944,405 (1960) July 12.

Vapor losses in storage tanks are prevented by a system which comprises a vapor pipe from a vapor space of the tank to the top of a conventional pipe-type heat exchanger and from the bottom of the exchanger back to the vapor space. The liquid stored in the body of the tank is pumped through the exchanger as a coolant, so that vapors are brought to equilibrium temperatures with the bulk of the stored liquid, and excessive pressure and vacuum in the vapor space is avoided.

How to Determine Low-Temperature Storage Costs. J. T. Horton. *Petrol. Refiner 39,* 115 (1960) July (4 pp.)

Results from an extensive computer study, shown in graphical form, permit rapid selection of the most economical type of storage at optimum conditions. Basic criteria for engineering design of LPG storage are: safety and economy. The engineer's job is to find the most economical design compatible with these two criteria. While this study is devoted to storage of liquefied petroleum gas — generally mixtures of hydrocarbons from C_2 to C_5 — it is also applicable to other products which are gaseous at ordinary conditions.

Tanks

Prestressed Concrete Steel Lined Tanks Are Leak-Proof Bomb-Proof. *Pipe Line News 32,* 38 (1960) July (4 pp.)

Description is given of 12 new underground storage tanks at a million-barrel jet fuel depot at Ozol, Calif. Besides their leak-proof quality, these tanks are designed to withstand blast loading resulting from a possible nuclear explosion at the earth's surface. Steel-lined prestressed concrete was the medium selected to meet these conditions. The prestressing was accomplished by helically wrapping the concrete tanks with wire under tension.

Underground Storage

Benefits Are Universal in Underground Gas Storage in Michigan. H. L. Fruechtenicht. *Gas Age 126,* 26 (1960) July 21 (5 pp.)

Underground storage has provided the last economic link between distant markets and sources of supply. Underground storage facilities in Michigan provide 10 times as many more customers gas for space heating than could be served by pipeline deliveries and local gas production alone. Capital cost is less than one-third that of a pipeline system to provide the same supply. Article describes suitable reservoir formations in Michigan and gives a few suggestions on how regulation can help storage systems give their full benefit to users of natural gas.

Conducting Chemical Reactions in an Underground Storage Cavern. H. V. Hess, and E. R. Christensen (assigned to Texaco Inc.) U.S. 2,939,895 (1960) June 7.

Process is claimed for conducting chemical reactions in large underground caverns such as may be washed out of salt or clay beds. After pumping out as much of the aqueous brine as possible, its deleterious effect upon the desired reaction is prevented by forming a barrier layer of insoluble plastic (buna rubber, chlorinated rubber, methacrylate polymer). This is formed *in situ* by dissolving the polymer in ketone, glycol, or petroleum solvents. The reacting material, paraffins or olefins, may be isomerized, alkylated, cyclized or polymerized by pumping it on top of the barrier layer, with addition of proper catalysts. The mixture is held at 100-200°F and pressures to 1000 psi, by surface heat exchange and compressors, for the time needed for reaction.

Dual Storage Caverns. H. V. Hendrix (assigned to Phillips Petroleum Co.) U.S. 2,934,904 (1960) May 3.

Two underground, salt-washed cavities, communicating at their lower ends, are used to store two different fluids. One fluid, in relatively great supply, is forced into one cavity, forcing an immiscible sealing fluid (brine) downward, and into the other cavity to displace the other fluid which is in relatively short supply. The fluids may be LPG and gasoline.

Simultaneous Underground Gas Storage and Secondary Oil Recovery. W. F. Burke. *J. Petrol. Tech. 12,* 22 (1960) July (5 pp.)

Article discusses unexpected oil recovery from supposedly depleted reservoirs which were converted to gas storage by a transmission company. Data on oil recovery from gas storage reservoirs in the New York City and Ambassador fields are included.

7. MANUFACTURED GAS AND CHEMICAL PROCESSING

Aromatics

Naphthalene Extraction Process Utilizing Polynitro Aromatic Compounds as Complexors. F. Veatch, R. W. Foreman and J. A. Gecsy (assigned to The Standard Oil Co.) U.S. 2,941,017 (1960) June 14.

Process is claimed for recovery of fused polycyclic aromatic compounds such as naphthalene from petroleum refinery hydrocarbons. This comprises forming a complex between the aromatic and a "complexor" which remains dissolved or suspended in a solvent. The complexor may be a polynitro aromatic compound, such as picric acid, or 3,5-dinitro salycylic acid. This complexor must be dissolved in a solvent, such as water or ethylene glycol, which is immiscible with the main petroleum liquids. The complexor solution and raw hydrocarbon are mixed by stirring the two liquid layers separated by decanting for 0.1 to 10 minutes, and the complex solution layer is treated by distillation, permitting recovery of naphthalene as overhead or residue, depending on the solvent.

Coal Gasification

The Kinetics of Carbon Gasification. J. D. Blackwood. **Part 2.** *Coke and Gas 22,* 250 (1960) June (5 pp.); **Part 3.** *Ibid.,* 293 (1960) July (5 pp.).

In Part 2, the author discusses the reaction of carbon with hydrogen and the role of the water-gas shift reaction in gasification. Part 3 is concerned with the reaction of carbon with carbon dioxide and dissociated gases. Since carbon dioxide is produced during the oxidation of carbon by free oxygen, its reduction by carbon will not take place until all the free oxygen has been consumed. More detailed studies of the reaction have led to the conclusion that surface complexes must be formed and that these complexes break down to give carbon monoxide. At higher temperatures the complexes break down rapidly and the reaction rate is controlled by chemisorption.

Process for the Production of Fuel Gas. H. V. Rees, C. G. Ludeman and F. B. Sellers (assigned to Texaco Development Corp.) U.S. 2,942,959 (1960) June 28.

Carbonaceous fuel is partially combusted with oxygen-containing gas at 1800°-3500°F and at a pressure of 700 psig to form carbon monoxide and hydrogen. This hot raw gas is passed with steam (0.7 mol water/atom of C) through a fixed bed to reduce terminal gas temperature to 100°-1700°F, to give a gas high in methane (25-40%) and of high Btu (425-600).

South Africa-Installation for Complete Gasification Taken Over. *Gas J. 302,* 552 (1960) June 29 (4 pp.)

Article describes installation and commissioning of two complete gasification plants for the City of Johannesburg Gas Department. System represents culmination of work begun in 1955 when the possibility of utilizing local coals which exhibited poor coking and weakly caking properties by a complete gasification process was investigated. Each of the two units subsequently ordered is capable of producing 2 MMCF/day of gas at 450 Btu/CF. Each unit comprises a gasifier, carburetter, superheater and waste heat boiler. The gasifier includes a dry seal mechanical grate, driven through a hydraulic system, an annular boiler, retorts and an automatic coal charger. The gasifier is of particular interest: coal is fed from an overhead storage bunker by way of a lock hopper into a number of retorts above the generator.

Underground Gasification of Coal by Air: Interpretation of Physico-Chemical Principles. K. Dziunikowski. *J. Inst. Fuel 33,* 337 (1960) July (7 pp.)

Principles involved in evaluating the processes which take place in the underground gasification of coal are described. From the results certain physico-chemical phenomena occurring in the underground gas producer are interpreted. The heat balance is calculated and likewise the heat loss to the surrounding rocks. From the results of work with experimental underground gas producers in Poland, carried out by the method described, conclusions as to the effectiveness of the underground gasification of coal by air are drawn.

Coal Hydrogenation

The Mechanism of Coal Hydrogenation. F. J. Pinchin. *BCURA Monthly Bull. 23,* 465 (1959) Dec. (12 pp.)

Storch *et al.* have carried out detailed kinetic investigations leading to the clear conclusions that the function of the catalyst is to increase the rate of regeneration of the hydrogen donor, and that the main rate controlling reaction is between the hydrogen donor and the oxygen and unsaturated groups in the coal. Attempts to find more active catalysts which permit the use of lower temperatures (and hence lower hydrogen pressures) have not been successful, and if the above conclusions are true they would not increase the rate of the controlling action. From the work described in this

review it seems unlikely that it will be possible to lower significantly the pressures at present required for the liquefaction process, even though Lahiri *et al.* reported a reduction from 200 atm to 30 atm for the reaction giving improved coking properties. Gasification of coals in hydrogen at higher temperatures (900°C) and at pressures of about 50 atm appears more practicable.

Hydrogen

Conversion of Hydrocarbons to a Hydrogen-Rich Gas. C. K. Mader (assigned to M. W. Kellogg Co.) U.S. 2,943,062 (1960) June 28.

Apparatus for conversion of gaseous hydrocarbons is claimed in which the improved feature comprises a reduced central nozzle for feeding oxygen, with mixing vanes to diffuse and mix it with gas tangentially introduced through an annulus in a mixing chamber. The main reaction occurs in a catalyst bed below the mixing space.

A Superfuel . . . Liquid Hydrogen . . . from Refinery Off-Gas. P. D. Fuller and I. A. Cornwell. *Petro. and Chem. Eng. 32,* C-6 (1960) July (6 pp.)

For a number of years the manufacture of liquid hydrogen for use as a rocket fuel has been classified for security reasons. Now most of the details of the first plants have been released, including data on the pioneer production unit designed, built, and operated in California. Use of refinery off-gas instead of base raw materials eliminates the need to manufacture hydrogen gas, and thus greatly reduces investment requirements, operating costs and phasing-in problems at start up time.

Hydrogenation

Catalytic Hydrogenation of Phenols. N. I. Shuikin and L. A. Erivanskaya. *Uspekhi Khimii, Progress of Chemistry (U.S.S.R.) 29,* No. 5, 648 (1960) (20 pp.) (From Assoc. Tech. Services, Inc.)

Review covers: hydrogenation of phenols to hydroaromatic alcohols and ketones, reduction of phenols to aromatic hydrocarbons, preparation of hydrocarbons, hydrogenation of polyhydroxy phenols, and destructive hydrogenation of higher phenols with the formation of lower ones.

Oil Gas

Gasification of the Crude Oil from Hassi-Messaoud and Production of Gases Substitutable for Natural Gas from Petroleum Products. A. Salvadori, P. Lovy and M. Beigelman. (Assoc. Tech. de l'Ind. du Gaz en France, 1960 Congress; 41 pp. French text.)

Divided into two parts, the paper first discusses the gasification of crude oil from Hassi-Messaoud. Cracking and reforming with water vapor in the presence of alumina and a nickel-base catalyst lead to gases which are directly substitutable for town gas. Thermal cracking in the presence of water vapor, with or without air, on silicon carbide, gives rich gases whose calorific power can reach 1570 Btu/CF. Part II discusses experiments in connection with a method of producing gases of the second family, substitutable for natural gas by a process of catalytic autohydrogenation of rich gases whose hydrogen and nonsaturated hydrocarbon contents are of the same order.

Heating Gases and Vapours. A. G. Carter (assigned to Power Gas Corp. Ltd.) U.S. 2,944,806 (1960) July 12.

Process of heating gases to high temperatures is claimed, which comprises two separate heat-storage zones, each with an adjoining combustion zone and connected by a conduit at the hot end and having conduits and valves to a stack at the cold (lower) end. The cycle comprises preheating air during its passage upward through the first zone; burning with atomized fuel at the top of the second zone, and heating the second regenerator by down-moving products passing to the stack. Then steam is heated by this zone and leaves the side-outlet at the top connecting duct. Also, the steam may be used here in oil gasification at the top (hot) end, with final cracking of oil in the first zone. The heating cycle then is reversed, beginning by preheating air in the first zone.

Production of Town Gas by Catalytic Gasification of Petroleum Products, Using Fine-Grain Heat Conductors, According to the Lurgi-Ruhrgas Continuous Process. W. Wustrow, H. Kratz and O. Madrich. (Assoc. Tech. de l'Ind. du Gaz en France, 1960 Congress; 7 pp. French text.)

The Lurgi-Ruhrgas process is characterized by a continuous transport of the reaction heat for the cracking and reforming of hydrocarbons, using solid heat conductors. Process was developed primarily for the manufacture of olefinic hydrocarbons by the cracking of petroleum products, and an industrial-scale installation is now in operation at Dormagen for the manufacture of 20,000 ton/yr of ethylene using fine sand as the heat conveyor. The process has been further developed for the gasification of petroleum products into town gas, substituting catalyzing masses for the sand. Paper gives account of the tests conducted on the modified unit.

Several Oil Gasification Methods. G. Cronier. *Svenska Gasverks. Manadsblad, 45* (1960) No. 5 (7 pp. Swedish text.)

Review of four of the modern oil gasification processes which have been discussed in the *Manadsblad* since 1955. Gas results, analyses and discussions are grouped as metal tube, ceramic chamber and catalyst bed, and cyclic systems as used in Europe on lighter liquid hydrocarbons.

Pyrolysis

Process for the Pyrolysis of Hydrocarbonaceous Material. A. S. Parker and M. P. Sweeney (assigned to United Engineers and Constructors Inc.) U.S. 2,939,893 (1960) June 7.

Improvement is claimed in a process for pyrolysis of solid or liquid hydrocarbon material wherein the material is first contacted with a stream of entrained inert solids at 2000°F. The solids are separated and the gas-

eous materials mixed with hot gas for a second heating. The improved method comprises forming the second stage hot gas by heat exchanging an added gas (steam) with the separated solids of the first stage which have been highly heated (2500°-3200°F) by combustion of injected oil and of coke deposited on the solids.

Pyrolysis of Coal and Shale in the Review Year 1959. Pyrolysis of Coal. M. Gomez. *Ind. Eng. Chem. 52*, 717 (1960) Aug. (4 pp.); **Oil Shale Pyrolysis.** C. H. Prien. *Ibid.*, 720 (1960) Aug. (4 pp.)

European carbonization research continues to explore the fundamental aspects of the pyrolysis reaction. In the U.S., emphasis is being given to the development of processes for the conversion of low-rank western coals to metallurgical grade coke. Intensive basic and applied oil shale research continues in the USSR. Bibliography includes 123 items.

Thermal and Catalytic Decomposition of Hydrocarbons. A. J. deRosset and C. V. Berger. *Ind. Eng. Chem. 52*, 711 (1960) Aug. (6 pp.)

Availability of hydrogen from catalytic reforming has stimulated interest in hydrocracking. Four research groups have published details for such processes. Feeds treated range from heavy naphtha and light cycle oil to vacuum distillate and topped crude. The objects are to prepare reformable gasolines of high cyclic content, as well as higher boiling fractions suitable for distillate fuel, for recycle to the process or for conventional fluid and moving bed catalytic processing.

Reformed Gas

The C.C.R. Process. *Coke and Gas 22*, 298 (1960) July (4 pp.)

Already firmly and successfully established in the U.S. and Continental Europe at more than 30 large-capacity commercial installations, the U.G.I./CCR process is now available to Great Britain, Australasia and South Africa. Article gives brief description of the CCR (cyclic catalytic reforming) process, its operation and application.

Cyclic and Catalytic Reforming of Natural Gas in the U-G-I Lines at Lyons. C. Jungbluth and L. Chabrouty. (Assoc. Tech. de l'Ind. du Gaz en France, 1960 Congress; 12 pp. French text.)

Report describes the plant at LaMouche which cracks the gas that flows from Lacq to Lyons. The plant is equipped with two cyclic/catalytic reforming lines operating on the U-G-I system, each capable of producing 240,000 Nm^3 of gas at 3400 cal/day or of operating at lower power off butane or propane. Special emphasis is given to the method used in operating a U-G-I line.

Cyclic Cracking of Methane and Light Petrol in the "Stein and Roubaix" Lines at the Plants at Nantes and Saint-Brieu. A. Blaizot and G. Guichard. (Assoc. Tech. de l'Ind. du Gaz en France, 1960 Congress; 13 pp. French text.)

First of two parts deals with the plant at Nantes, noting the final adjustments and modifications made, and indicates the initial results obtained by putting into operation two of the MS_{34} lines having a rated capacity of 110,000 CM/day at 4200 mth/CM. Part II discusses the two MS_{31} lines at Saint-Brieu which in 1959 were re-equipped to enable them to utilize light petrol for the production of gas capable of being substituted for the usual 4200-cal town gas. All the different types of light petrol supplied by the refineries have been tried.

Design and Tesing of an Industrial P_9 Generator Prototype. J. Reboul and M. Picard. (Assoc. Tech. de l'Ind. du Gaz en France, 1960 Congress; 16 pp. French text.)

Description of the prototype of a P_9-type generator enabling a new method for the cyclic reforming of hydrocarbons. Principles and operation are described, and the results obtained with commercial propane are given. Tests in reforming gasoline are to be carried out.

Use of Refinery Residual Gases by the Normandie Group of Distributors. S. Philippart and C. Papault. (Assoc. Tech. de l'Ind. du Gaz en France, 1960 Congress; 20 pp. French text.)

Refinery residual gases now constitute an important source of raw materials for the gas and chemical industries. Two of the refineries in the Lower Seine, Esso Standard and the Cie Francaise de Raffinage, are currently supplying the Gaz de France piping network with some 600,000,000 thermal units of residual refinery gas each year. This gas is either sold unprocessed or else is converted into town gas in cracking plants at Le Havre (cyclic cracking of the ONIA-GEGI type) and at Grand-Quevilly (autothermal cracking of the Grand-Paroisse type). Report gives data concerning the refinery gases supplied and describes the two cracking methods.

Synthesis Gas

Process for the Conversion of a Normally Gaseous Hydrocarbon to Carbon Monoxide and Hydrogen. J. B. Dwyer (assigned to M. W. Kellogg Co.) U.S. 2,942,958 (1960) June 28.

Normally gaseous hydrocarbons are converted to mixtures rich in hydrogen and carbon monoxide by reacting the former with oxygen and steam. The reaction occurs at 1800°-2200°F and at 150-350 psig in a fixed catalyst bed of refractory coated with nickel oxide, at a velocity of 50-150 fps.

8. GAS DISTRIBUTION

Distribution Systems

Construction of an Overhead Network Made of Brazed Aluminium Alloy for the Distribution of Gas at Medium Pressure. J. Soulet and A. Tournon. (Assoc. Tech. de l'Ind. du Gaz en France, 1960 Congress; 10 pp, French text.)

Description is given of the construction work for a medium-pressure gas distribution network made of

brazed aluminium alloy, carried out as an experiment at the Perigueux Distribution Center. The purpose of the program was to develop a technique that would enable aluminium to be used for the construction of an overhead distribution network, and to assess the economic benefits to be derived from the use of this material.

High Density Polyethylene Pipe for Low Pressure Gas Systems. L. B. Croley. *Gas Age 126,* 17 (1960) July 21 (5 pp.)

Detailed review of the characteristics of high density polyethylene pipe from the standpoint of its use in gas systems, methods of joining, field installation techniques, installation economics, performance history in gas gathering and some advantages for low-pressure gas distribution.

Renovation of the Distribution Network in the City of Marseilles. H. Jouanolou and G. Combarel. (Assoc. Tech. de l'Ind. du Gaz en France, 1960 Congress; 22 pp, French text.)

Paper describes what has actually been achieved and spent in completely renovating a portion of the Marseilles distribution network by the fitting of Piedfort R.J. flanges, the modification of certain sections to which flanges could not be adapted, and the cleaning of all pipes. The renovation process is described, and the results of the program are discussed. Discussion also includes field work, problems and rate at which work proceeded. Authors believe that renovation program was preferable to replacement program.

Utilization of Thin Steel Pipes and Tapping on T.G.A. Feeder Mains when Installing Medium-Pressure Networks. P. Grolleau and J. Benoist. (Assoc. Tech. de l'Ind. du Gaz en France, 1960 Congress; 13 pp, French text.)

Paper describes 1) use of thin steel pipe for medium-pressure gas distribution and 2) application of an original method of pretapping the pipes in which the form of pretapping employed is so designed that when a feeder main is connected, the conventional drilling operation on the main is replaced by the simple punching of a cap. The advantages of this method are safety and ease.

Gas Conditioning

Industrial Experiments in Gas Conditioning by Humidification and Oil Vapour. P. Asselineau. (Assoc. Tech. de l'Ind. du Gaz en France, 1960 Congress; 19 pp, French text.)

Gas conditioning tests consisting of the use, in the vapor phase, of a product rich in methylnaphthalene—NAM oil—were carried out on three distribution networks (Hyeres, Libourne and Romilly) when they were converted. By way of experiment, this technique was associated in certain cases to a humidification or decreasing benzoling of the gas. The objects of the tests were 1) to perfect a number of pieces of conditioning apparatus, and 2) to ascertain the effectiveness of the products and techniques employed. The apparatus consisted of: 1) a Drouvin type; 2) a Knoertzer type; and 3) a Speichim type. All three pieces operated satisfactorily, and the characteristics of each are described.

Leakage

A Statistical Study of Leaks in Gas Networks. J. Tonnellier. (Assoc. Tech. de l'Ind. du Gaz en France, 1960 Congress; 18 pp, French text.)

Objective of study was to determine what proportion of a network it would be profitable to recondition, providing the leakage level were known. Since, in this case, direct measurement data on the leakage levels in separate sections of several networks were available, it was possible to conduct a statistical study of the distribution leakage levels within these sample networks. Then a simple criterion was drawn which, in a first approximation, emerges as a linear law relating that percentage of a given network it would be profitable to recondition to the average leakage level on the same network.

Tests for Localizing Leaks in Building Installations by Odorization of the Gas. A. Courbebaisse and R. Wettstein. (Assoc. Tech. de l'Ind. du Gaz en France, 1960 Congress; 6 pp, French text.)

Authors describe an experiment in odorizing gas with "Spotleak," carried out at Saint-Etienne, to enable gas leaks in building installations to be localized. Leaks thus detected and repaired already total 600 for a network serving 35,000 consumers. Total expenditure incurred for the tests was 250,000 francs. Results obtained appear highly encouraging and the method promises to be fairly widely applicable.

Mains

New Method of Gas Main Repair. R. Mercier. *J. Ind. Gaz 84,* 243 (1960) June (8 pp. French text.)

Description of a new method of gas transmission pipeline repair which can be effected without shutdown of the line.

Training Main Layers and Service Layers. *Gas Times 94,* 39 (1960) June; **Success of Eastern Gas Board Training Scheme.** *Gas World 152,* 137 (1960) July 23.

Brief description of the Eastern Gas Board's (Great Britain) program which applies to all main layers or service layers' mates with more than 12 months of service. One-week practical instruction course includes marking out trenches, excavating, timbering and back filling, with emphasis on safety precautions and first aid practices.

Odorization

Laboratory Experiments on the Odorization of Gas. O. Angleraud. (Assoc. Tech de l'Ind. du Gaz en France, 1960 Congress; 11 pp, French text.)

Paper reviews a study of commercial odorizers carried out to orient odorization tests conducted on networks and on high-pressure branch lines. The tests proved that the sulfur type of compound offers properties best suited for the purpose. Among these are: adequate odorizing capacity; low chemical reaction; low retention by rust; low degree of absorption by oil mists or inhibitors; and good chemical stability.

Weather Forecasting

A Statistical Study of Gas Emissions in the Paris Area in Winter. P. Renouard. (Assoc. Tech. de l'Ind. du Gaz en France, 1960 Congress; 13 pp, French text.)

Statistical study of gas emission in the Paris area in winter brings to light the various factors which affect this emission. Due to an inertial effect, the previous day's temperature affects the emission level of the day under consideration; this emission is linked in linear fashion with a so-called "fictitious" temperature which is a function of the temperature of the day being considered and the previous days. A study also is conducted of the influence of wind, of each particular day in the week, of the position of the day with respect to the whole winter and of low temperature. In this way it is possible to determine the emission of any given day with an error of less than 4%.

9. GAS FUEL UTILIZATION AND APPLIANCES

Absorption Cooling

An Air-Cooled Absorption Cycle. R. H. Merrick and R. A. English. *ASHRAE J. 2,* 39 (1960) Aug. (3 pp.)

Description of newly developed air-cooled absorption cycle being used in 3 and 4½-ton gas-fired air conditioning equipment. Ammonia-water is the refrigerant-absorbent combination. Unusual features of the cycle are the use of a hermetic transfer device to circulate solution and a solution-cooled rectifier piped in parallel with the heat exchanger to improve cycle efficiency. A new cycle development was required as a review of familiar cycles disclosed too many limitations, as pointed out by the authors.

Air Pollution

Catalytic Oxidation of Hydrocarbons. K. C. Stein, J. J. Feenan, G. P. Thompson, J. F. Schultz, L. J. E. Hofer and R. B. Anderson. *Ind. Eng. Chem. 52,* 671 (1960) Aug. (4 pp.)

Removal of hydrocarbons from automobile exhaust gases by means of a catalytic muffler requires adequate oxidation catalysts. A survey of 18 single-component oxide catalysts showed that those of cobalt, nickel, manganese, chromium and iron are the best. Aromatic, branched aliphatic, normal aliphatic, olefinic and acetylenic hydrocarbons were, in general, increasingly easy to oxidize, in the order named. These results suggest the most promising types of catalysts and indicate which types of hydrocarbons will be most difficult to eliminate.

Cleaner Air for North Carolina. B. C. Blakeney and M. D. High. (North Carolina State Board of Health, Sept., 1959, 62 pp.)

Cooperative survey conducted by the North Carolina State Board of Health, with technical assistance from the U.S. Public Health Service, has as its objective a more comprehensive air pollution prevention program for the state. Recommendations made at the end of the survey attack the problem through education, technical assistance, research and legislation. Cooperation of groups, starting with local levels and progressing to the state level, is stressed.

Process of Oxidizing Carbon Monoxide and Hydrocarbon in Exhaust Gases. L. P. Elliott (assigned to California Research Corp.) U.S. 2,942,932 (1960) June 28.

Process is claimed for preventing air pollution by incompletely burned exhaust products of automobile engines, in which hot oxidizing catalyst beds are used. During startup or cold-engine periods up to 800°F, the gases are first passed through an adsorption zone containing activated charcoal and then through the oxidation catalyst. After attaining 800°F, the exhaust is passed through an eductor with added air, and then through the catalyst (potassium dichromate).

Process of Oxidizing Carbon Monoxide and Hydrocarbons in Exhaust Gases. A. H. Batchelder and R. P. Sieg (assigned to California Research Corp.) U.S. 2,942,933 (1960) June 28.

Process described differs from that in U.S. Patent No. 2,942,932 (preceding) in that a catalyst system without adsorbent is claimed.

Burners

Gas Burner. B. W. Taylor (assigned to Fisher Scientific Co.) U.S. 2,942,655 (1960) June 28.

Gas burner, particularly useful for glass blowing, is claimed in which the burner body contains a number of bored passages designed to mix the gas and oxygen. These passages are designed to converge so that the gas jets meet at a core where they merge into a stable flame.

Controls

Design of Pneumatic Control Centers. R. J. Caffrey. *Air Conditioning, Heating and Ventilating 57,* 69 (1960) Aug. (7 pp.)

Knottiest problem in design of control centers is to determine how much supervision and control is warranted. After explaining basic components of the pneumatic system, author considers the criteria of budget, comfort standards, and convenience in the layout of a control center for a typical small office building.

High-Force Thermostatic Actuators. J. S. Freismuth and J. K. Gould. *Prod. Eng. 31,* 74 (1960) July 11 (5 pp.)

Versatile wax-filled thermal controls are now competing successfully with conventional liquid- and gas-filled bulb-and-bellows actuators. They are available from several manufacturers, with a choice of thousands of performance characteristics. Authors explain how they work, compare them with other types, and present design guide for putting them to work.

Serviceability of Combustion Control Equipment Improved by Design Changes. R. Esslen. *Gas Age 126,* 24 (1960) July 21 (3 pp.)

Two control factors are vital to trouble-free operation of most gas-fired furnaces and open-fired heat-processing equipment: accurate maintenance of constant air/gas ratio and of the delivery pressure of the mixture. Article describes recent design improvements instituted by Selas Corp. of America which assure attainment of both factors over extended periods of time.

Cookers

Gas Range. G. W. Kamin (assigned to Cribben and Sexton Co.) U.S. 2,939,453 (1960) June 7.

For a counter, or "built-in," top-burner gas range unit, a boxlike casing is claimed, with top surface extended at the edges to support unit in the counter. Burner openings are provided in the rearward top surface, and a recessed tray is provided at the front top surface. The recessed tray provides space for the row of burner-valve knobs, which are positioned below the cooking surface and which are kept cool by flow of combustion air through the perforated tray walls to the primary air shutters of the burners in the box below.

Furnaces

Modernized Forge Shop Solves Many Problems for New Jersey Plant. R. H. Franklin. *Ind. Gas 39,* 2 (1960) July (2 pp.)

Prior to modernization of plant facilities, there were seven oil-fired furnaces installed in the forge shop. When re-equipping the shop these furnaces were rebuilt and converted to gas, and 14 additional gas-fired furnaces were installed. The furnaces are equipped with a low-pressure inspirator set rated at 915 million Btu/hr.

Industrial Heating

Automatic Machine Brazing of Stellite Inserts to Turbine Blades. J. van Opynen. *Ind. Heating 27,* 1368 (1960) July (5 pp.)

Article describes the steps involved in preparing the turbine blade for a Stellite insert and the actual method employed to effect the insert.

One Example of the Gas Revolution in the Potteries. E. Ford. *Gas J. 303,* (Gas in Ind. Sect.) 182 (1960) July 6 (8 pp.)

Description of company in Great Britain, well-known for its production of larger forms of electrical porcelain, and its use of gas-fired equipment. The company utilizes about 320 MMCF/year of gas. This is used to generate the proper temperatures for drying the raw material at various stages in the production process and for the firing of the final product. Very careful heat control is necessary because at several points, close limits of moisture content must be observed.

Operation of Automatic Mechanical Combustion Systems —Carburetor Type. G. Kier. *Ind. Heating 27,* 1407 (1960) July (5 pp.)

Greater precision in combustion control is being attained through use of automatic mechanical combustion systems featuring the proportioning of air and gas. Some details concerning such systems are given.

Ovens

Gas-Fired Ovens Play Large Part in Efficient Production of Automotive Brake Bands. A. Q. Smith. *Ind. Gas 39,* 8 (1960) July 2 pp.)

Accurately sized pieces of lining are coated with a thermo-setting cement in an automatic machine and conveyed through a direct gas-fired circulating convection oven heated to 150°F on a drying cycle of approximately two hours. The linings pass through two oven zones, each of which has its own external air heater. The heaters of each zone have a 300,000 Btu input through high-pressure inspirator burners to heat the large volume of air circulated by two blowers.

Wall Member for Heated Compartment. G. W. Kamin (assigned to Cribben and Sexton Co.) U.S. 2,939,452 (1960) June 7.

Insulating closure, such as a door for an oven or broiler, is claimed. This comprises an inner liner, spaced from an outer panel, both fastened to a support-frame such as a lower rail, or a drawer front, with limited metal-to-metal contact of panels and insulation material between panels.

Pilot Lights

Lighter System for Gas Burners. E. J. Blanzy (assigned to Lincoln Brass Works.) U.S. 2,941,588 (1960) June 21.

Pilot lighting system for gas burners is claimed, which comprises small pilot feeder tubes supplying larger terminal tubes carrying individual pilot burners. Each pilot burner is comprised of a fine, hollow-needle tube passing through the plugged end of the terminal tubes to provide a small fat flame in a cuplike shield placed near a side port of the particular burner.

Refrigeration

Absorption Refrigeration. W. G. Kogel (assigned to Aktiebolaget Electrolux.) U.S. 2,942,431 (1960) June 28.

Absorption refrigeration improvement is claimed in which a generator or vapor-expulsion unit of the system has a liquid column with its surface maintained at a level below that at which liquid is introduced by a vapor-liquid lift pump. The liquid from the column overflow may be recirculated through the pump, thus diverting it from the absorber.

Space Heaters

Modern Flats Have Central Heating by Gas. *Gas 23,* 17 (1960) June (2 pp.)

Description of the recently completed block known as Richmond Court in Wellesden Lane, London, which consists of nine one- and two-bedroom flats with floor areas of 650 to 800 sq ft. Each flat has its own self-contained central heating by means of a wall-mounted

Ascot G 728 gas-fired unit with forced circulation of hot water through a system of seven or eight single and twin Steelrad panel-type radiators on a ½-in. copper two-pipe circuit.

Ventilation

Sizing of Vent Pipe and Chimneys for Gas Appliances. E. H. Perry. (New York: A.G.A., Project DA-5-HA, Res. Rep. No. 1300, June 1960.) $1.50.

Design procedures are presented for individual and multiple gas vent systems. Suggested multistory vent design procedures are given in the appendix. Main factors considered are vent and vent connector materials, vent connector configurations, size and height of vent pipe or chimney and appliance rated input. Sample problems are solved to illustrate the methods of calculation for several types of vent systems.

Venting of Gas Appliances. C. C. Turner. *LP-Gas 20,* 30 (1960) July (4 pp.)

Excellent review of appliance venting covering chimneys, type B vents and vent connectors, together with inspection and maintenance procedures, is presented.

10. EQUIPMENT AND INSTRUMENTATION

Computers

Better Computer Solution of Multicomponent System. A. M. Peiser. *Chem. Eng. 67,* 129 (1960) July 11 (5 pp.)

Article presents method of tower closure that has been in productive use on a computer for over two years and that has been applied to rating and design of several hundred towers. Regarding convergence, it can be reported that the method has never failed to lead to the correct solution. A rigorous proof of convergence has not been found for the general case, but it has been proved that the procedure will converge under mildly restrictive mathematical conditions that can be reasonably well satisfied in actual practice.

Pneumatic Black Boxes . . . Simple Computers for Process Control. P. H. Stirling and H. Ho. *Ind. Eng. Chem. 52,* 65A (1960) Aug. (3 pp.)

Improvement of automatic process control, which is the next logical step after acceptance of a monitoring display, has been accomplished in many places usually with electronic analogs. Emphasis on the use of high-speed electronic computers has obscured the fact that there are many cases where slower response of pneumatics is adequate. Many simple computations can be carried out using available pneumatic devices. All the basic computing operations are available in pneumatic guise.

Use Computers to Select Exchangers. D. L. Gulley. *Petrol. Refiner 39,* 149 (1960) July (8 pp.)

Article is written as a guide in deciding whether a computer has economic justification. A sample program is proposed to show the steps to take in rating a typical exchanger. Author's aim is to help reader decide the minimum computer size for his purpose. The sample program and heat transfer information are reduced to a form the computer can use.

Fluid Flow

Measurement of Fluid Flow. P. Scanes (assigned to George Kent Ltd.) U.S. 2,941,402 (1960) June 21.

This measuring device for fluid flow applies the principle of mass flow, in which a pivoted-blade driving rotor is used to set up a balancing torque in a sensing rotor with blades fixed parallel to the flow. The balancing torque results from rotation of weights linked to the common shaft, and reacts through a gear-toothed sleeve upon the driving rotor. A counter spindle, geared to the common shaft, permits the rate of rotation to be integrated as a measure of mass flow.

Instruments

Development in Weighing. *Instrumentation and Control Systems 33,* 1145 (1960) July (7 pp.)

Newest developments for various weighing devices are discussed, illustrated and listed by companies.

Piping

Considerations Involved in Choosing Plastic Pipe for Corrosion Control. L. F. Sansone, Jr. *Corrosion, 16,* 336t (1960) July (3 pp.)

Evaluation is made of the properties of thermoplastic materials which make them useful for piping applications. The outstanding property of plastic materials, and their chemical resistance to a broad range of inorganic and certain organic compounds, is discussed. Test methods and various types of attack observed are discussed to aid in the choice of a suitable material on the basis of chemical resistance. Physical limitations of thermoplastic materials are pointed out in order that they may be utilized in the area where they are best suited. Examples of several applications are given where plastic pipe has been utilized to solve corrosion problems.

Process Design

What Refinery Simulation Involves at Phillips. E. W. Mills. *Oil Gas J. 58,* 85 (1960) July 4 (4 pp.)

Company uses process flow calculations to simulate total refinery operations. This technique avoids the explanation and examination of complex mathematics before plant personnel can use the simulation. Dynamics of individual unit operations can be expressed accurately and in detail. Optimum techniques and linear programs can be included as a part of the over-all program whenever desirable.

Pumps

High Temperature Canned Pumps. H. A. Thornton and A. D. Fell, Jr. *Chem. Eng. Progress 56,* 45 (1960) July (4 pp.)

Canned pumps offer design engineers advantages in high pressure and temperature heat transfer applications in the chemical processing and nuclear industries. Recent technological progress in supplying heat to chemical and industrial processes, heating buildings and cooling nuclear reactors has led to the wide use of various heat transfer liquids at relatively high temperatures and sometimes high pressures. Increased efficiencies are obtained and smaller systems can be used as a result of the high heat content that is developed in the system.

Thermoelectric Devices

Thermoelectric Devices. W. Huck. *ASHRAE J. 2,* 42 (1960) Aug. (4 pp.)

Interest in thermoelectricity today is divided between pumping heat and generating electricity. There are many similarities in these two fields; the major difference is in goals. Several companies have built heat pump devices ranging from bottle coolers and warmers to room air conditioners. Although appliances such as these are not merely scientific curiosities, they are still not economically feasible. Reasons for high costs are that laboratory rather than production methods have been used to date.

Valves

"Cinderella" Ball Valves Strike It Rich in CPI. G. Weyermuller and G. Bangs. *Chem. Processing 23,* 34 (1960) Aug. (3 pp.)

Known but ignored since the time of the Caesars, the ball valve has suddenly emerged as a glamour girl of American business. First spotlighted by their use in missiles, these valves in industry have now rocketed from $5 million sales in 1959 to $20 million in 1960 with resounding acceptance in the world of chemical processing.

11. MATERIALS OF CONSTRUCTION, AND CORROSION

Cathodic Protection

Design for Pipelines. D. Spector. Part 1. *Corrosion Tech. 7,* 103 (1960) Apr. (4 pp.); Part 2. *Ibid.,* 213 (1960) July (5 pp.)

Part 1 covers preliminary technical considerations encountered in planning cathodic protection for the 6-in. Haifa—Tel Aviv product line and the 16-in. crude oil line from Ashdod to Haifa. The second part includes specific design problems and an illustrated description of the installation work and commissioning. Special attention has been paid to the design of report and other forms suitable for each phase of the work.

Coatings

Coating Systems Suitable for Thin-Scantling Construction. R. S. Capp and B. J. Philibert. *Corrosion 16,* 34 (1960) July (3 pp.)

Little change has been made in the coatings used on ships in 50 years. Extensive surveys recently made showed heavy damage suffered from corrosion of internal members of ships because of improper coatings. Reasons for poor painting of ships' insides are given. Current high-speed, light scantling ships do not have the safety factor formerly available in heavier construction, so closer attention to coating integrity is needed if severe damage is not to be suffered. Some examples of recent welded ship hull construction are given, with reasons for the poor performance of conventional coatings. New coatings, especially mastics, offer considerable advantage for interior surfaces subject to stress and movement and damage from salt water condensation. Examples of effective coating practice are given. A list of reasons for closer attention to ship corrosion problems is given. Some needed new materials are defined.

Flame-Cleaning Method Used on British Gas-Filled Holder. J. Grindrod. *Gas Age 126,* 33 (1960) July 7 (2 pp.)

New method of cleaning a gas holder prior to painting has been used successfully in Britain at the Leamington Spa Gas Works of the West Midlands Gas Board (Warwickshire Division). This 80-ft. diameter holder was cleaned while it still contained gas by using a special flame-cleaning method after other methods had previously been tried without success. The new method involves the use of the strip cleaning technique of passing the flame over the metal surface in conjunction with ancillary descaling equipment in order to avoid overheating and distortion.

Testing Procedures for Cold Applied Coal Tar Coatings. W. E. Kemp and J. J. Lane. *Pipe Line News 32,* 53 (1960) July (4 pp.)

Many problems in protective coating systems have their origin either as to the intent of the coating specification or failure to recognize that specification interpretation does exist. Problems arising from specification interpretation are not confined to any particular type and can arise from both hot and cold applied systems.

Corrosion

Corrosion Problems at Lacq Sour Gas Field. M. Estavoyer. *J. Inst. Petrol. 46,* 223 (1960) July (11 pp.); **Engineering and Design Problems Affecting Cathodic Protection of Lacq Field Well Casings.** *Corrosion 16,* 14 (1960) Aug. (5 pp.)

Article describes how corrosion problems influenced the design of production equipment at Lacq field. A balance sheet showing the behavior of the installations with regard to corrosion after two years of exploitation is included. It can be seen how these results affect the improvement of the equipment.

Some Corrosion Problems in Ships. R. S. Capp and B. J. Philibert. *Corrosion, 16,* 22 (1960) July (7 pp.)

Although considerable progress has been made in reducing corrosion of exterior ship hulls and tanks, little progress has been made on superstructure or interior surfaces. The use of thin scantling and thin shelled construction for high speed ships makes the internal corrosion problem more important than ever. Mild steel hulls now generally used must have a coating of high integrity if they are to resist corrosion even when

cathodic protection is provided. Problems associated with decks, dissimilar metal fittings, aluminum superstructures, bilges, voids, and other internal areas are discussed. Examples of corrosion damage are reported because of poor coatings. The problems peculiar to space behind fitted instruments and furniture, especially those involving insulation, are discussed. How decks corrode under covering presently used is described.

An Experimental Investigation of Fuel Additives in a Supercharged Boiler. R. J. Zoschak and R. W. Bryers. *J. Eng. Power 82,* 169 (1960) July (12 pp.)

To permit the use of high-vanadium residual oil as fuel for combined super-charged-boiler gas-turbine power plants, it is necessary to determine the treatment required to prevent the high-temperature corrosion and deposit problems associated with this fuel. A test program has been undertaken wherein a number of magnesium and aluminum-bearing additives have been injected into washed residual oil when firing a laboratory-scale, simulated supercharged boiler. Different tube arrangements within the boiler have been tried. Ash collected on the tubes at various locations has been analyzed and its corrosive effect at high temperatures on some types of stainless steel has been evaluated. The results thus far obtained are presented together with some hypotheses regarding the formation of deposits.

External Corrosion of Superheaters in Boilers Firing High-Alkali Coals. P. Sedor, E. K. Diehl and D. H. Barnhart. *J. Eng. Power 82,* 181 (1960) July (13 pp.)

In the past few years, corrosion of high-temperature superheaters and reheaters has become an increasingly serious problem on coal-fired boilers. A type of corrosion that has occurred on several boilers in the Chicago area which burn high-alkali coal is described. The results obtained from an experimental study of the factors influencing the rate of attack and the control measures applied are described.

Pipes and Fittings to Beat Corrosion. *Corrosion Tech. 7,* 220 (1960) July (4 pp.)

Increasing interest in corrosion protection and prevention is evidenced by the fact that some 40% of the stands at the first Pipes and Pipelines Exhibition (London) were in some way concerned with the manufacture of corrosion-resistant pipes. The development of new industries, and the discovery of new processes and chemicals all demand better performance from pipes and related fittings. That these demands are being met is shown from this review.

Reaction Velocity in the Corrosion of Iron by Hydrogen Sulfide and the Effect of Inhibitors. G. S. Gardner. *Corrosion 16,* 312t (1960) July (7 pp.)

Reaction rate of iron and hydrogen sulfide has been studied in an oxygen-free system in the presence of sodium chloride brine, in the presence and absence of an oil phase under a constant mixing rate at 40°C and 80°C. The experimental data are plotted according to a previously derived equation for the ion-acetic acid system, and are shown to be in agreement with that equation. Another group of measurements on the iron-hydrogen sulfide system was carried out in the presence of corrosion inhibitors. There seems to be some possibility that good inhibitors function by forming a particularly efficient nonpermeable adsorbed film with iron sulfide corrosion products.

Inhibitors

Refinery Corrosion Rates Below 5 mpy Achieved by Chromate Water Treatment. W. A. Hess. *Corrosion 16,* 18 (1960) July (3 pp.)

Article describes water treatment tests conducted to control corrosion to a maximum of 5 mpy at a refinery's catalytic reformer. Corrosion rates obtained in two proprietary systems are compared: chromate and phosphate. Analyses of well water used and the circulating water in the two treatments are given in tabular form.

Metals

Austenitic Stainless Steels. J. H. McConnell and R. R. Brady. *Chem. Eng. 67,* 125 (1960) July 11 (4 pp.)

The thousands of tons of stainless used in liquid-oxygen production and storage testify to its practicality for service at −320°F. One investigator showed why it is so popular in this field: after a 15-year exposure in liquid-oxygen service, a Type 303 valve stem still had an impact strength of 25 ft-lb at −292°F. Article includes tables and graphs of stainless steel properties.

Low Temperature Piping Materials. H. M. Howarth. *Petro and Chem Eng. 32,* C-33 (1960) July (8 pp.)

Primary consideration in the selection of materials for low temperature is how to avoid brittle fracture. Much has been published, but it is impossible to predict with complete reliability when brittle fracture will occur. To date, brittle failure has generally been attributed to the notch sensitivity of the material at the operating temperature. The most widely used test is the notched-bar Charpy impact test. The criterion for acceptance established by most code bodies is the arbitrarily selected value of absorbed energy of 15 ft-lb in a 10 mm by 10 mm keyhole notched specimen at the service temperature. It is convenient to divide low temperature service into different temperature ranges when talking about materials. Materials for the ranges −150°F, −150° to −50°F and −50°F to −20°F discussed, and codes and properties are tabulated.

How to Obtain ASTM A 333C from Normalized A 106 B and A 53 B. M. Van Blaricom. *Petro and Chem Eng. 32,* C-24 (1960) July (7 pp.)

Replacement of scarce steel piping for use at −50°F is discussed, and the ASTM specifications and the influence of metallurgical properties and treatment are outlined.

Nickel

Materials of Construction for Chemical Plant—Nickel. J. Hinde. *Chem. and Process Eng. 41,* 295 (1960) July (7 pp.)

This, the third article in a series on "Materials of Construction for Chemical Plant," deals with nickel, a very expensive metal. This factor alone prevents its acceptance as a general-purpose material of construction. The combination of excellent corrosion resistance with high mechanical properties, however, has made nickel and nickel alloys irreplaceable for many process vessels. Article describes the properties of nickel, monel, inconel and other nickel alloys and discusses the usefulness of these materials to the chemical plant constructor.

12. ANALYTICAL METHODS AND TESTS

Aromatics

The Use of Ozonolysis in Oil Constitution Research. II. Side-Chain Analysis of Aromatics and Benzothiophenes from Various Oil Fractions. H. Boer. *J. Inst. Petrol. 46,* 234 (1960) July (3 pp.)

Ozonolytical method for determining side chains in aromatic molecules has been applied to a variety of straight-run distillates, catalytic reformates, and aromatics obtained by hydrodesulfurization of benzothiophenes. The distribution of side chains in aromatics from straight-run gasoline fractions of widely varying crudes turns out to be quite similar: in all cases 70-80% of the substituents are methyl groups, 10-20% ethyl groups, and 0-10% propyl and butyl groups. Comparable group distributions are found for catalytic reformates. Benzothiophenes occurring in straight-run gas-oil fractions (bp 290°-325°C) were found to be substituted most frequently in the 2-position.

Chromatography

Direct Determination of C_3 to C_5 Hydrocarbons in Olefinic and Nonolefinic Gasolines by Gas-Liquid Chromatography. D. D. Zakaib. *Anal. Chem. 32,* 1107 (1960) Aug. (4 pp.)

New gas-liquid chromatographic method allows the direct determination of C_3 to C_5 hydrocarbons in gasolines. Measurements of peak area are made for the light hydrocarbons and the backflush C_6+ hydrocarbon components of the sample. Nonolefinic gasolines are analyzed in 25 min, while complex olefinic samples require about an hour.

Gas Chromatographic Determination of C_6, C_7 and C_8 Olefins According to Their Carbon Structures. K. H. Nelson, W. J. Hines, M. D. Grimes and D. E. Smith. *Anal. Chem. 32,* 1110 (1960) Aug. (5 pp.)

Olefins of the C_6, C_7 and C_8 carbon structure are determined by gas chromatographic technique. The sample mixture is analyzed for individual paraffins and naphthenes before and after hydrogenation. The difference between the analyses represents the olefins having the carbon structure of the corresponding paraffins and naphthenes, and is reported as a sum.

Removal and Identification of Organic Compounds by Chemical Reaction, in Chromatographic Analysis. R. Bassette and C. H. Whitnah. *Anal. Chem. 32,* 1098 (1960) Aug. (3 pp.)

Selective chemical reactions are used in conjunction with gas-liquid chromatography for the separation and identification of organic compounds from mixtures. Chromatographic peaks are systematically eliminated by adding various reagents to the complex mixture. The prefractionation technique is applicable for the separation of impurities prior to use of mass spectrographic analysis.

Dust

Use of Membrane Filters for Determining the Size of Dust Agglomerates as They Actually Exist in a Gas Stream. L. J. Kane, H. C. Wright and C. C. Shale. *U.S. Bur. Mines Rep. Invest. 5637,* (1960, 30 pp.)

Conventional methods for determining the size of dust suspended in a gas require that agglomerates first be broken into particles, but in evaluating the industrial dust-removing equipment the size of the agglomerates as they actually exist in the gas stream is far more important. The size and size-distribution of agglomerates as they exist when the gas reaches the filter was determined by using a membrane filter in conjunction with a dust count under a microscope. The filter used is a cellulosic sheet about 150 microns thick containing millions of holes per sq cm—holes of uniform diameter that run directly through the sheet without interconnection. Results of the investigation are presented.

Hydrocarbons

Determining Density Variation of Light Hydrocarbon Mixtures. J. K. Elliott and P. H. Kelly. *J. Petrol. Tech. 12,* 170 (1960) July (5 pp.)

Data accumulated enables the development of a set of liquid density curves which relate density to pressure, temperature and molecular weight. These curves make it possible to predict density variation with pressure and temperature. Compared to extensive laboratory compressibility data on a complex, light hydrocarbon liquid, the use of the liquid density curves resulted in an average error of less than 0.5%.

Hydrogen Sulfide

Continuous Proportioning of the Total Sulphur Content in the Purified Lacq Gas. F. Brisse and B. Pflugfelder. (Assoc. Tech. de l'Ind. du Gaz en France, 1960 Congress; 8 pp, French text.)

Paper describes the continuous analyzer used as a monitoring device to ensure a continuous proportioning of the hydrogen sulfide, total sulfur and gas humidity contents of Lacq gas after purification and degasolining. The proportioning is accomplished by a continuous hydrogenation followed by a conductimeter-type, conventional hydrogen sulfide analyzer. The relative gas, hydrogen and reactive-liquid flows are maintained constant by volumetric-type pumps driven by a common motor. The scale of measurement achieved is from 0 to 50 mgr/cu m.

Mass Spectrometer

Least-Squares Treatment of Spectrometric Data. H. A. Barnett and A. Bartoli. *Anal. Chem. 32,* 1153 (1960) Aug. (4 pp.)

Least-squares procedure applied to spectrometric data indicates the simultaneous determination of coefficients required to calculate concentrations of all components in a mixture from observed absorbances at selected wave lengths. The method is applicable to mass spectrometric data from the analysis of light oil fractions.

Methane

Absorption Spectra of Solid Methane, Ammonia, and Ice in the Vacuum Ultraviolet. K. Dressler and O. Schnepp. *J. Chem. Phys. 33,* 270 (1960) July (5 pp.)

Vacuum ultraviolet spectra of solid ammonia and ice are found to be shifted to higher frequencies relative to the corresponding vapor spectra by 7000 cm^{-1}. The effects of hydrogen bonding in the ground states of these solids, and the nature of repulsive interactions possible in the excited states are discussed. In methane, which forms a pure van der Waals solid, the spectra of gas and solid are found to be very similar.

Nitrogen

Sensitive Spot Test for Nitrogen Compounds in Petroleum Fractions. P. V. Peurifoy and M. Nager. *Anal. Chem. 32,* 1135 (1960) Aug. (3 pp.)

Rapid spot test is developed for determining the nitrogen content of petroleum fractions. Sample spot is placed on a filter paper and sprayed with tetracyanoethylene in benzine. After oven drying at 110°C, the color is compared with color of knowns. Limit of detection is about 10^{-7} g.

Sulfur Oxides

Collection of Sulfuric Acid Mist in the Presence of a Higher Sulfur Dioxide Background. Comparison of the Electrostatic Precipitator, the Greenburg-Smith Impinger, and the Sintered-Glass Filter. J. V. Kerrigan, K. Snajberk and E. S. Anderson. *Anal. Chem. 32,* 1168 (1960) Aug. (4 pp.)

Comparison study is conducted to establish the relative abilities of the electrostatic precipitator, the Greenburg-Smith impinger, and the sintered-glass filter for collecting sulfuric acid mist found in polluted air. The instruments are efficient at high or low concentrations of sulfuric acid in an atmosphere of high sulfur dioxide content.

13. BASIC SCIENCE

Absorption

Absorption with Chemical Reaction. A. J. Teller. *Chem. Eng. 67,* 111 (1960) July 11 (14 pp.)

Because of the complexities involved in the mechanism of absorption accompanied by chemical reaction, no rigorous analytical method of design has been developed. However, large numbers of empirical relationships have been developed for specific systems and a limited number of operating variables. Theories, reactions, diffusion rates and packings are discussed in much detail, with MEA absorption of CO_2 as an example.

Adsorption

Adsorption and Its Application to Solvent Recovery. D. J. Spikins. *Chem. and Process Eng. 41,* 277 (1960) July (5 pp.)

Difference in mechanism between absorption and adsorption is defined and the two types of adsorption are discussed. Work on adsorption rates and equilibria is mentioned and a method for the calculation of heats of adsorption is given. A review is given of theories of adsorption, and the general principles of the application of adsorption to solvent recovery are described.

Design of a Continuous Counter-Current Adsorber. F. Molyneaux. *Chem. and Process Eng. 41,* 285 (1960) July (4 pp.)

Mass transfer operations for solid-fluid systems include adsorption, drying and leaching. Whereas drying and leaching have been extensively studied as chemical engineering unit operations, adsorption has so far received inadequate attention. Author discusses adsorption as a unit operation in order to design from basic principles a continuous countercurrent adsorber for removing impurities from dry-cleaning solvents. This original approach should prove particularly useful in developing continuous solvent recovery techniques.

The Submonolayer Adsorption of Argon and Krypton on Molybdenum Disulfide; Phenomenological Comparison with Studies on Graphite. P. Cannon. *J. Phys. Chem. 64,* 858 (1960) July (4 pp.)

Adsorption isotherms of argon and krypton in the submonolayer coverage region on samples of hexagonal molybdenum disulfide are reported. Extensive experimental detail is given, since this constitutes the first such report. Two different temperatures for degassing lead to different results, since oxide contamination is volatile at an intermediate temperature. A comparison of results with those published for graphitic substrates points out the conditions necessary for MoS_2 to behave as a homogeneous surface.

Fluid Flow

An Extended Reynolds Analogy. W. Squire. Proc. 6th Midwest Conf. Fluid Mech., Austin, Texas, Sept. 1959; Austin Uiv. Press, 16-33. (From *Appl. Mech. Rev. 13,* 512 (1960) July.)

Previous formulas of heat transfer in a circular pipe are discussed specially for the high and low Prandtl number range. A simple derivations is proposed, assuming mainly a temperature defect law similar to the velocity defect law, both laws being supposed to apply to the entire cross section except for the laminar layer at the wall. Besides dropping the law of the wall, paper abandons usual criterion locating edge of the laminar layer.

The Theory of One-Dimensional Two-Phase Flows of Incompressible Fluids. J. C. Martin. *Producers Monthly 24,* 18 (1960) July (11 pp.)

Article represents an attempt to develop some of the more general mathematical relations involved with two-phase flows to a point where they may be attacked by known methods. Article is specifically concerned with one-dimensional flows. Some of the methods are outlined and solutions to some simple problems are presented. While the published works contain a great deal of information, there appears to be many more results which can be obtained by applying well known mathematical methods to the equations which govern two-phase flows.

Gases

Normal Atmospheric Pressure. J. K. Brasch. *Air Conditioning, Heating and Ventilating 57,* 93 (1960) July (5 pp.)

Elevation of an air handling system often makes a great difference in design calculations. Engineers should know the derivation of so-called "standard" variation of atmospheric pressure and temperature in order to apply values correctly.

Heat Transfer

On Non-Stationary Heat Transfer through a System of Disks, Rotating in a Viscous Liquid. G. A. Tirskii. *Izv. Akad. Nauk SSSR, Otd. Tekh Nauk,* 106 (1958) July (2 pp. Russian text.) (From *Appl. Mech. Rev. 13,* 512 (1960) July.)

Paper deals with a system of large coaxial disks rotating at different and variable angular speeds, and they are placed between two stationary end disks. Only the method of solution is given, the final result being in the form of partial differential equations to be solved numerically.

Liquefaction

Design and Construction of a Liquid Hydrogen Temperature Refrigeration System. D. B. Chelton, J. W. Dean and B. W. Birmingham. (Washington: U.S. Dept. of Commerce, NBS Tech. Note No. 38, 1960, $.75.)

Maintaining a liquid hydrogen bubble chamber at 27°K has been achieved with an automatically controlled closed circuit hydrogen refrigeration system of 300 watts capacity. The system is sufficiently flexible to be used on other experimental equipment requiring refrigeration at liquid hydrogen temperatures. Several control systems are discussed. Experimental evidence is compared to predicted performance for design operating conditions. General design charts are developed that enable heat exchanger lengths and associated operating parameters to be determined for the pertinent heat exchanger configuration when employed in liquid hyrogen refrigerators of other capacities.

Methane

A One-Center Wave Function for the Methane Molecule. A. F. Saturno and R. G. Parks. *J. Chem. Phys. 33,* 22 (1960) July (6 pp.)

Slater orbitals, centered on the carbon nucleus and having variable orbital exponents and principal quantum numbers, are used to construct electronic wave functions for the ground state of the methane molecule. Values for the five linear coefficients, the seven orbital exponents and the seven principal quantum numbers are determined by the variational method. The total molecular energy obtained from a one-term wave function of this form is −39.50 a.u.; the five-term result is −39.80 a.u.; the experimental nonrelativistic energy is −40.51 a.u. Comparison with a similar calculation for the neon atom indicates that most of the residual error is in correlation energy, and it favors the high value for the sublimation of carbon.

Nitrogen

A Note on the Thermal Conductivity of Solid Nitrogen and the Direct Condensation of Nitrogen Gas into a Solid. K. Karamcheti. AFOSR TN 59-183 (Univ. So. Calif., Eng. Center Rep. 56-206; ASTIA AD 211 323), 13 pp. Jan. 1959. (From *Appl. Mech. Rev. 13,* 509 (1960) July.)

To estimate the condensation rate (i.e., the mass of nitrogen condensed per unit of time) per unit area of the surface, the problem is treated from the point of view of one-dimensional unsteady heat conduction through the growing layer of the solid condensate. An analytical solution to the problem is obtained.

From author's summary

Phase Equilibria

Equilibrium in the Methane-Carbon Dioxide-Hydrogen Sulfide-Sulfur System. H. T. Kennedy and D. R. Wieland. *J. Petrol. Tech. 12,* (Tech. Paper 8120) 166 (1960) July (4 pp.)

Sulfur content at equilibrium is reported for pure methane, carbon dioxide, hydrogen sulfide, and on three binary mixtures of each of the three pairs of gases at pressures of 1000, 2000, 3000, 4000, 5000 and 6000 psia and at temperatures of 150°, 200° and 250°F. In addition, the sulfur content of three ternary mixtures at the same temperatures and pressures are reported. Results indicate that the sulfur content is higher in the gases at higher temperatures and pressures. The content is highest in hydrogen sulfide, intermediate in carbon dioxide and lowest in methane.

Water

On the Caloric Properties of Water at Pressures up to 500 kg/cm² and Temperatures up to 300°C. A. M. Sirota and P. E. Beliakova. *Teploenergetika 6,* 67 (1959) No. 10 (4 pp. Russian text.) (From *Appl. Mech. Rev. 13,* 510 (1960) July.)

New experimental data on the c_p of water are compared with results of measurements by other authors and with the results of calculating c_p according to p, v, T data. The enthalpy of water has been computed for pressures up to 500 kg/cm² and temperatures to 300°C.

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American Chemical Society, Journal of
American Gas Association Monthly
American Gas Journal
American Institute of Chemical Engineers, Journal of
American Society for Testing Materials Bulletin
Analytical Chemistry
Appliance Manufacturer
Applied Chemistry, Journal of
Applied Mechanics, Journal of
Applied Mechanics Reviews
Applied Physics, Journal of
Applied Spectroscopy
ARS Journal
ASHRAE J.
Australian Journal of Applied Science
Australian Journal of Chemistry

Basic Engineering, Journal of
Battelle Technical Review
Bituminous Coal Research
Brennstoff-Chemie (German)
British Coal Utilization Research Association Monthly Bulletin and Quarterly Gazette
Business Week
Butane-Propane News

California Oil World
Canadian Chemical Processing
Canadian Gas Journal
Canadian Journal of Chemical Engineering
Canadian Journal of Chemistry
Canadian Journal of Physics
Ceramics (British)
Chemical and Engineering Data, Journal of
Chemical and Engineering News
Chemical & Process Engineering
Chemical Education, Journal of
Chemical Engineering
Chemical Engineering Progress
Chemical Physics, Journal of
Chemical Processing
Chemical Reviews
Chemical Society, Journal of (British)
Chemical Society, Proceedings (British)
Chemical Week
Chemistry & Industry (British)
Coal-Heat
Coal Utilization
Coke and Gas (British)
College Placement, Journal of
Combustion
Combustion and Flame (British)
Communications of the ACM
Compressed Air
Computers and Automation
Construction Methods and Equipment
Control Engineering
Corrosion
Corrosion Technology (British)
Cost Engineering
Datamation
Design News
Drilling
Electronics
Engineering for Industry, Journal of
Engineering for Power, Journal of
Engineers' Digest (British)
Erdöl und Kohle (German)
Faraday Society, Transactions of (British)
Fuel (British)
Fuel Efficiency (British)
Fueloil & Oil Heat
Gas
Gas Age
Gas & Oil Power (British)
Gas Council Research Communications (British)
Gas Heat and Comfort Cooling
Gas Industries
Gas Journal (British)
Gas Service and Domestic Coke
Gas Times (British)
Gas- und Wasserfach (German)
Gas World (British)
Gazovaya Promyshlennost (Russian)
Heating, Piping & Air Conditioning
Heat Transfer, Journal of
Independent Petroleum Association of America Monthly
Industrial and Engineering Chemistry
Industrial Finishing (British)
Industrial Gas (American)
Industrial Gas (British)
Industrial Heating
Industrial Research
Industries du Gaz, Journal des (French)
Institute of Fuel, Journal of (British)
Institute of Gas Technology Research Bulletins
Institute of Petroleum, Journal of (British)
Institution of Gas Engineers Bulletins and Communications (British)
Instrumentation
Instruments and Control Systems
Izvestiya Akademii Nauk S. S. S. R. Otdelenie Khimicheskikh Nauk (Russian)
Khimiya i Tekhnologiya Topliva i Masel (Russian)
LP-Gas
Lubrication
Lubrication Engineer
Mathematical Aids to Computation
Mechanical Engineering
Metals, Journal of
National Aeronautics and Space Administration Memorandum
National Fire Protection Association Quarterly
National Gas Bulletin of Australia
National Petroleum News
Nuclear Science and Engineering
Nucleonics
Oil and Gas Journal
Optical Society of America, Journal of
Organic Chemistry, Journal of
Petro/Chem Engineer
Petroleum (British)
Petroleum Engineer, The (Drilling and Producing)
Petroleum Engineer, The (for Management)
Petroleum Refiner
Petroleum Technology Journal of
Petroleum Week
Physical Chemistry, Journal of
Physics and Chemistry of Solids (British)
Physics of Fluids (British)
Physics Today
Pipeline Engineer
Pipe Line Industry
Pipeline News
Power
Producers Monthly
Product Engineering
Progress (Pakistan)
Public Utilities Fortnightly
Research/Development
Research, Journal of, A. Physics and Chemistry
Research, Journal of, B. Mathematics and Mathematical Physics
Research, Journal of, C. Engineering and Instrumentation
Review of Scientific Instruments
Revue Generale du Gaz (Belgian)
Rivista dei Combustibili (Italian)
Science
Scientific Instruments, Journal of (British)
Solid-State Electronics
Stroitel'stvo Truboprovodov (Russian)
Svenska Gasverksföreningens Månadsblad (Swedish)
Technical News Bulletin
U.S. Bureau of Mines Bulletins, Information Circulars and Reports of Investigations
U.S. Patents
Uspekhi Khimii (Russian)
World Oil
World Petroleum